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For the benefit of those members of the Association and friends of entomology who were not fortunate enough to hear the Fiftieth Anniversary greetings from Dr. Howard, transmitted by long-distance telephone, Dr. F. L. Campbell made arrangements to have the greetings recorded on a phonograph record. This record is now at Ohio State University and it is hoped that opportunity may be presented for present and future entomologists to hear the voice of the well-loved Chief of American Entomologists.

In order that all may know the content of this message, couched in the informal language of a friend among friends, a transcription has been secured and is here reproduced. The thanks of the Association are due Dr. Howard for his permission to print the message.

Dr. Howard's Anniversary Greeting to the Entomologists of America

GREETINGS TO EVERYONE PRESENT! I am very sorry that I cannot be with you, but I wish to send my special greetings to Professor Walker and Professor Mickel, President and Secretary of the Entomological Society of America, and also to Mr. Sasscer and Professor Cory, the President and Secretary of the Association of Economic Entomologists. Speaking of Mickel reminds me; Professor Mickel I wish to say a word to you personally. When you go back to Minneapolis, will you please give my warm sympathy to Mrs. Royal N. Chapman who has just suffered such a severe and unfortunate loss of her intelligent husband? He was too young to die. Tell her I sympathize with her deeply. He ought to have lived for many year to come.

Now I also send my special regards to the Chairman of your meeting, Professor Osborn. Osborn is a man for whom I have the greatest respect. I have it for many reasons. One is because he's older than I am. I have the respect due to old age then. You see he is 83 and I am only 82. Then, Osborn has a number of other advantages over me. For instance, he has a full head of hair, and I have no hair at all. He has a perfectly functional pair of legs, while my legs are absolutely bum. But then, all that is overcome by the fact that I've got it over him by being a founder of the Association of Economic Entomologists; he is only an original member.

Oh I wish I could be with you there and tell you all about it. I wish I could hear Avinoff's lecture tomorrow evening. I wish I could be at the dinner and hear Sasscer tell stories about the experiences of some of the officials of his service. They are so humorous, and Sasscer has a keen sense of humor. However, when you go back home, if you will get out the seventh volume of Insect Life, you will find my annual address as President of the Association of Economic Entomologists for 1894. The meetings were held in one of the small lecture rooms of the old Packer Institute in Brooklyn, New York and I think there were 17 members present and about 17 guests. Compare that with the size of the meeting you are holding today, for example. In all events, if you will read that address, (you needn't read it all) just read the opening paragraph giving an account of the general meeting and the final paragraph giving my own ideas about the future of economic entomology. And that will say all that I would have said if I could be there with you today. And so now I'll say goodbye, goodbye!

Transcript from a phonograph record made by Dr. L. O. Howard on March 2, 1940, reproducing as well as he could his remarks telephoned from Washington, D.C. to Columbus, Ohio and heard by the entomologists assembled at the symposium on 50 years of economic entomology, December 27, 1939.

BOOK REVIEWS

The Bionomics of Entomophagous Insects, Part II, by Walter Valentine Balduf, Planograph, Pages 1–384, John S. Swift Co., Inc., St. Louis —Chicago—New York—Cincinnati, 1939.

This volume is a part of an amibitious project to bring into one series a digest of world knowledge in relation to the bionomics of entomophagous insects. The first volume, a work of 220 pages and issued in 1935, deals with the Coleoptera and the present one with the Lepidoptera, Trichoptera, Mecoptera and the Neuroptera.

Entomophagous insects are known to practically all entomologists. They are noticed mostly in an incidental way in a large proportion of the accounts of economic insects and as a consequence the literature is widely scattered and largely unavailable except to those who have unusual library facilities and the time, personal or through assistants, to follow this most interesting, and in some respects at least, economically important study. There is no question, for example, that many entomophagous insects are important checks either upon pests or potential pests. This digest may result in important developments in the control of insect pests of the future. Part I on Coleoptera, for example, has uncovered a field only dimly vizualized by most entomologists or biologists and the same is true of Part II with its discussion of four relatively important orders.

For the Lepidoptera there is a table listing a large number of cannibalistic caterpillars, another listing absolute predators, another of entomophagous parasites. The Lycaenidae, comprising the coppers, blues, and hairstreaks, are discussed in considerable detail, especially the relation of their larvae to ants. There is also a tabulation of the larval food and an extended list of the Myrmecophilous larvae. This is a key to one of the most interesting chapters in insect life. The author in his Part III on Lepidoptera discusses the rise of Entomophagy, dividing the various groups into Homopterophagous, Myrmecophagous, Homoptero-excretophagous, Excretophagous, Phytomyrmecophagous, Homoptero-myrmecophagous, and miscellaneous Entomophoga.

The treatment of the Trichoptera or Cadis flies is along similarly comprehensive lines and is especially interesting since it summarizes our knowledge in relation to a large, imperfectly known group and yet an extremely interesting one in its various bionomical phases. This, likewise, is a key to an extensive and scattered literature. The author gives an extended table of the food of Trichoptera larvae and there are numerous illustrations of the peculiar larval and pupal cases.

The remarkable Mecoptera, best known through the Scorpion flies, is covered in an equally comprehensive manner. It is a group rarely noticed except by students of biology or ecology.

The same general statements apply to the account of the Neuroptera, another group of more interest to the general biologist than to the average entomologist and yet extremely interesting because of its mostly aquatic habits and peculiar forms. The scope of the work is suggested by a tabulation of the food of Hemerobiid larvae, a table of the food of *Hemerobius pacificus* over a period of eight days, one of the cycles of Hemerobiidae, another of the food of Chrysopid larvae, one of the life cycles of Chrysopidae, an extended one of the life cycle of *Chrysopa carnea*, and one of the enemies of Chrysopidae. There are extensive bibliographies for the various groups and an admirable series of illustrations, many of them redrawn from the original publication by the author's wife and Miss Katherine Sommerman.

Entomologists, biologists, zoologists, and those interested in teaching by class or through public prints, will find in this volume a ready guide of world-wide scope to those phases of entomophagous insect activities in which they may be specially interested. The author has rendered a material service in the summation of this widely scattered literature and thereby laid a basis for more comprehensive studies of these diverse and in many cases really important insects.

E. P. Felt.

Fleas of Eastern United States, by Irving Fox. Iowa State College Press, Ames, Iowa. February, 1940. vii & 191 pp., 33 plates, containing 166 figs. Cloth bound, price $3.00 postpaid.

Students of fleas will find this a most useful book. It incorporates the many changes in generic division, species placements and family groupings which have been scattered through the literature since the last published summaries, that of Baker (1904) and the less complete one of Carroll Fox (1925). Fifty-five species are treated; keys are given, followed by literature summaries, descriptions, distribution and host data, and illustrations of pertinent characters for each species. Genitalia offer the best diagnostic characters and are well illustrated. Very useful also are the synonymic and host indices given on pages 111 and 114, and the book index and bibliography.

The author has made considerable effort to make this book usable to the beginning student of fleas, by helpful introductory matter on technique, terminology and morphology, and by lavish illustration of diagnostic parts. The student must realize, however, that only carefully cleared and well mounted specimens will show many of these differences. As in almost all other insect groups, there are places in flea taxonomy where difficult characters are the only ones available, and this is not the fault of the author. Here the student will find consultation of a specialist or reference collection a great help. It should also be born in mind that additional species may be found in the eastern United States at any time.

While this book has a great deal to commend it, the author could have improved the following points:

1. In attempting to make some keys phylogenetic, the author has sacrificed clarity of identification. This is exemplified by the key to suborders, based on the "fractured head" character; between the two extremes of this character transitional forms occur with which a novice is reduced to guesswork. It is unfortunate that more taxonomists do not realize that identification keys and phylogeny seldom mix satisfactorily.

2. Since the males of *Atyphloceras* and *Catallagia* are known, some provision should be made for them in the generic key.

3. The illustrations would be more accessible if mentioned directly in the keys and easier to compare if all drawings of the same part faced the same way. —2-29-40.

H. H. Ross, *Illinois Natural History Survey, Urbana, Illinois.*

CURRENT NOTES

E. Graywood Smyth Establishes Laboratory in California

Mr. E. Graywood Smyth, for nine years entomologist for the W. R. Grace Sugar Estates in Peru, has recently established his residence at Glen Ellen, California. His country home "The Perch," newly completed, on his Hillcrest Woods estate in the "Valley of the Moon," and his laboratory, are situated on a broad terrace overlooking Sonoma Mountain and the Jack London Ranch.

There will be deposited his private collection of more than 90,000 specimens, mostly beetles. This is to be accessible to visiting entomologists and collectors through the courtesy of Mr. Smyth.—1-28-40.

The Charles Robertson Collection to be at Urbana

The Charles Robertson collection of insects, one of the largest private collections in the state of Illinois, has recently been purchased by the Illinois State Natural History Survey, according to a statement made by Dr. T. H. Frison, Chief of the Survey.

Charles Robertson, now deceased, was for many years professor of Botany at Blackburn College, Carlinville, Illinois. He was a careful and able collector and preparator of insects and assembled his collection during a period of more than thirty years. Since the collection was the result, largely, of Professor Robertson's interest in the inter-relationships between insects and flowers it contains a large proportion of bees and wasps. Most of the material was local, collected in the Carlinville region. It comprises more than 30,000 pinned insects of which some 20,000 are bees and wasps. Included are some 200 type specimens.

The acquisition of this collection must be of great interest to entomologists and should be particularly valuable for the study of the bees and wasps of Illinois and the whole central states region.

The collection will be housed in the new Natural Resources Building when that structure is completed.—2-20-40.

James Troop Honored at Purdue

The Annual Dinner of the Thomas Say Entomological Society of Purdue University was held in honor of and on the date of Professor James Troop's 87th birthday, March 14. Professor Troop came to Purdue in 1884, ten years after receiving his master's degree at Michigan Agricultural College. For 28 years (1884–1912) he was head of the Department of Horticulture and Entomology, and for eight years (1912–1920) head of the Department of Entomology. Professor Troop was the first State Entomologist of Indiana, which office he held, in addition to his duties with Purdue University, from 1899 until 1907.

John J. Favinger, President of the Thomas Say Entomological Society, presided at the dinner and brief talks were made by Dean Fisher on "Troop as a Teacher," Prof. L. Greene on "Troop as a Horticulturist," and Prof. J. J. Davis on "Troop as an Entomologist."

Holton Appointed to the Bureau

Mr. J. C. Holton who, for the past twelve years has been Commissioner of Agriculture for the State of Mississippi has been appointed to the Bureau of Entomology and Plant Quarantine with headquarters at Denver.

Mr. Holton will be in charge of cooperative field activities of the bureau and will be especially concerned with those cooperative operations which involve the State Departments of Agriculture.

Rocky Mountain Conference of Entomologists

Notices have been sent out announcing the sixteenth annual Rocky Mountain Conference of Entomologists, to be held at the Cameron Pass camp, a rebuilt CCC camp about 74 miles west of Fort Collins, Colorado, August 18 to 23, 1940.

This camp is beautifully located near the top of the range where high altitude insect collecting is especially good. Accommodations will be such that all members of the family can enjoy an outing.

The principle topic for symposium discussion is "Insect taxonomy, its fundamental principles, methods and relations to other branches of biological science."

Any one desiring additional information should write the chairman, Dr. R. H. Painter, Kansas State College, or the secretary Dr. George M. List, Colorado State College, Fort Collins, Colorado.

Pacific Coast P. C. O's Hold Third Annual Conference

The third annual Pacific Coast Pest Control Operators' Conference was held at the University of California, February 22–24, Professor W. B. Herms again serving as director of the conference. G. A. Rader of Berkeley was general chairman. The three days were filled with worthwhile lectures and laboratory demonstrations dealing with major household and structural pest problems which are handled by commercial pest control operators. A total of 141 pest control operators, most of them from California registered for the conference.

Georgia Entomological Society

At the fourth annual spring meeting of the Georgia Entomological Society, held at Emory University, April 6, 1940, Mr. C. H. Alden was elected President Mr. Milledge Murphey, Vice-President, for the year 1940–41. Mr. Horace O. Lund continues as Secretary-Treasurer.

During the sessions, Mr. Lund presented the report of the State Survey Committee; Mr. Murphey discussed the Japanese Beetle in Georgia; Mr. P. W. Fattig spoke of his experiences in his long career as a collector. Beekeeping in Georgia was discussed by Mr. A. B. Hamlin, and Mr. J. E. Webb discussed and demonstrated some of the work of the State Fruit Pest Parasite Laboratory at Cornelia. The retiring President, Dr. P. M. Gilmer, spoke on the responsibility of the professional entomologist in the development of amateur entomology in America.

New Fellowship at Oklahoma

Continental Oil Company has established a fellowship in entomology at Oklahoma A. & M. College for cooperative research. Mr. H. T. Mailon, a graduate in entomology from Kansas University, has been appointed to the fellowship thus provided.

DE LEON VISITS PUERTO RICO

Mr. Donald de Leon, of the Forest Insect Division of the Bureau of Entomology and Plant Quarantine is spending a period in Puerto Rico as a guest of the Forest Experiment Station at Rio Piedras. While there he is to conduct a survey of the forest insects of the region.

SOUTHERN P. C. O.'s MEET

Eighty-nine pest control operators registered for the Second Annual Pest Control Operators' Conference held at Louisiana State University at Baton Rouge, Louisiana, January 29–31, under the direction of Dr. O. W. Rosewall. Twelve states were represented, including Alabama, Arkansas, Georgia, Illinois, Indiana, Louisiana, Minnesota, Mississippi, Missouri, New York, Tennessee and Texas. Prof. J. J. Davis, of Lafayette, Ind., was a visitor.

The lectures and discussions dealt with the principal pest problems of the southern states, with which the commercial pest control operator must deal, and included ants, rats and mice, termites, powder post beetles, clothes moths, cockroaches and ticks, as well as fumigation problems and the chemistry of insecticides.

HORTICULTURAL INSPECTION NOTES

ON JANUARY 9–10, 1940, a conference was held in Denver, at which representatives of the Bureau of Entomology and Plant Quarantine met with State Directors and Commissioners of Agriculture, and Directors of Extension, for the purpose of reviewing the grasshopper and Mormon cricket work of 1939, and developing a broad policy-making program of operations for the season of 1940. Several State leaders in grasshopper control in 1939 were present as well as representatives of other interested agencies. Eighteen States were represented. While the meeting concerned itself largely with matters of a policy nature, it was arranged to hold additional meetings in each State having a 'hopper or cricket control problem, in order to formulate memoranda of understanding under which control operations would be conducted in each State.

AS A RESULT of the Federal-State survey for the phony peach disease in the field season of 1939, the States of Indiana and Pennsylvania, as well as 24 formerly infected counties of other States, were found to be eligible for removal from the regulated areas under the standardized State quarantines, which provide for such release of areas when found free from the disease for a period of three years. The State of Alabama, in conformity therewith, revised its quarantine on February 20, 1940, to lift the restrictions from these States and counties.

A PUBLIC conference to consider the advisability of withdrawing the Federal quarantine against the Japanese beetle and ending Federal cooperation with the States for suppression of the beetle, was held in Washington, February 27. It was attended by nurserymen and plant quarantine officials from some 18 States, and also by the Chief Plant Quarantine Officer of the Dominion of Canada. A great deal of interest was manifested in the proposed revocation of the quarantine, and with the exception of one speaker, all were in favor of its maintenance, and some indicated a desire that its enforcement be strengthened by additional measures and funds.

THE California Department of Agriculture on December 23, 1939, revoked the grape phylloxera quarantines issued in 1934, pertaining to both intra-state and interstate movement of the host plants, the pest having become quite generally distributed in the grape producing areas of California. Ample authority is provided in the Agricultural Code, it is pointed out, for the requirement of destination treatment of vines destined to be planted in non-infested areas.

INFESTATIONS of the olive scale in Fresno County and in five cities in other California counties, are the subject of restrictions set forth in quarantine circular No. 91, of January 25, 1940, issued by the California Department of Agriculture.

A PUBLIC hearing was held in San Juan, Puerto Rico, on February 14, 1940, to consider the advisability of prohibiting or restricting the entry into that island of unroasted coffee beans, as well as fruits, plants, and leaves of the coffee plants from all foreign countries, owing to the existence in various countries of the world of the coffee berry borer, *Stephanoderes hampei* Ferr., of which *S. coffeae* Hgdn. is a synonym, and an injurious rust, *Hemeleia vasatrix* B. & Br., as well as other injurious insects and plant diseases. This hearing was called by the Secretary of Agriculture under the provisions of the Plant Quarantine Act.

UNDER a revision of regulation 2 of the Federal quarantine relating to fruits and vegetables (No. 56), the entry of fruits and vegetables from Newfoundland and its mainland territory of Labrador is placed on the same status as those from Canada, with the exception of potatoes, which have long been and still are excluded entry from Newfoundland on account of potato wart. The amendment became effective February 27, 1940.

NOTICE

SECRETARIES and other officers of Branches, Sections, Affiliated Societies and Entomological Organizations not affiliated with the *Association* are invited to send in items which may be of interest to the economic entomologists. Notices of meetings to be held and brief account of meetings which have been held are particularly desirable. Advance notices will be inserted at as late a date in the preparation of a number of the JOURNAL as is possible but should be sent in early so that interested entomologists may have plenty of time to arrange to attend.

A special section, paralleling that devoted to *Horticultural Inspection Notes*, is to be arranged for notes from Branches and Sections and from other organizations.

Notes reaching the editor at an early date can be included in the June number of the JOURNAL. Notes should ordinarily be sent to the Associate Editor, Mr. Harry B. Weiss, at Trenton, New Jersey, but, when time is short, may be sent directly to the editor at Morgantown, West Virginia.

PROCEEDINGS OF THE ELEVENTH ANNUAL MEETING

EASTERN BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hotel New Yorker, New York, N. Y., November 16 and 17, 1939

The meeting was called to order by the Chairman, Clyde C. Hamilton, who presided until the middle of the second day, after which the new Chairman, W. H. White, conducted the closing session. The program contained 36 titles and in addition there was a joint session with the National Pest Control Association during the afternoon of November 16, containing 10 titles. There were two regular business sessions and at the end of the last day there was an additional one. An informal conference on the Codling Moth, presided over by Dr. D. L. Van Dine, was held on the evening of the first day of the meeting. In the following account the proceedings of these sessions have been combined. Over two hundred members and guests attended the meetings and Mr. E. R. Sasscer, President of the American Association of Economic Entomologists, spoke briefly of plans for making the forthcoming Columbus meeting successful and urged attendance.

The Chairman, C. C. Hamilton, appointed the following committees:

Committee on Nominations: Harry F. Dietz, Chairman, E. R. Sasscer, W. E. Blauvelt.

Auditing Committee: L. A. Stearns, T. L. Guyton.

Committee on Resolutions: C. H. Hadley, Chairman, Charles E. Palm.

Mr. H. B. Weiss, before presenting his Financial Statement, reported upon the membership from various states, which was holding up well, in comparison with previous years, and called attention to the good financial condition of the Branch. He also stated, for the record, that the first or 1938, award of the Eastern Branch for notable contribution to the science of economic entomology was made to E. H. Siegler and Lyle D. Goodhue, both of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, for their paper "Effect of Particle Size of Some Insecticides on Their Toxicity to the Codling Moth Larva," which was published in the Journal for April, 1939.

REPORT OF SECRETARY-TREASURER
FINANCIAL STATEMENT

Balance on hand, November 21, 1938			$1,778.04
Receipts			
Additional Dues for 1938	$ 134.00		
Receipts, Sale of Space in *Entoma* ane Sales of *Entoma*	2,437.35		
Dues for 1939 to November 10, 1939	78.00		
Interest on Savings Account	13.01		
Total Receipts		$2,662.36	$4,440.40
Disbursements			
Lantern operator, Baltimore	$ 30.00		
Clerical services—			
Eastern Branch	20.75		
Entoma	112.35		
Postage—			
Eastern Branch	19.82		
Entoma	191.70		
Printing—			
Programs, Baltimore meeting	20.50		
Entoma	731.00		
Other, in connection with *Entoma*	25.50		
1938 Proceedings	297.64		
Cut for 1939 Program	2.93		
Stationery—Eastern Branch	3.25		
Expenses of Secretary	9.03		
Award payments (2)	75.00		
Engraving of award medals	3.50		
Total Disbursements			1,542.97
Balance on hand, November 10, 1939			2,897.43
Distributed as follows:			
Savings Account No. 17424, Trenton Trust Co.	$1,020.51		
Checking Account, Trenton Trust Co.	1,876.92		
	$2,897.43		
Bills Collectible $245.25			
Treasurer's Balance, November 10, 1939	2,897.43		
Chairman of Finance Committee's Balance, November 1, 1939	39.95		
Total	$2,937.38		

HARRY B. WEISS
Secretary-Treasurer

The following were elected to affiliated membership:

Herman L. Fellton, Flushing, N. Y.
Raimon L. Beard, New Haven, Conn.
Samson R. Dutky, Moorestown, N. J.
R. T. White, Moorestown, N. J.
G. S. Weiland, Springfield, Ohio.
John H. Guill, Baltimore, Md.
Fred M. Snyder, New York, N. Y.
Chas. F. Opitz, Long Island City, N. Y.

Upon motion by E. N. Cory, the Branch approved the payment of $200.00 yearly to the Secretary-Treasurer, beginning with the present session.

The reports of the following committees and the report of the Secretary-Treasurer were all adopted by the Branch.

REPORT OF THE FINANCE COMMITTEE

November 1, 1938 to November 1, 1939

The Finance Committee, or more properly speaking, the Editorial Committee for *Entoma*, started work in the fall of 1938 towards publishing the third edition of *Entoma*. The chairman was ably assisted by all members of the committee but most especially by Neely Turner who took charge of the section on listings, and by Dr. R. C. Roark, who supervised the revision of the section on "Information on Insecticides and Fungicides."

Several noteworthy changes were made in *Entoma*. All old information was completely revised. A special effort was made to make the listings cover all parts of the United States and as complete as possible. A new section dealing with a "List of Trade Marked Insecticides, Fungicides and Adjuncts" was added. A "List of Insecticide and Fungicide Manufacturers and Accessory Companies" was also added. Probably the most radical change was the distribution of the advertisements throughout the listings. An effort was made to place these advertisements adjacent, or close, to listings of importance to the advertiser. This change was well received by the advertisers.

Entoma has shown a healthy growth. The first edition, in 1935, contained 102 pages, the second edition, in 1937, 144 pages and the third, or 1939, edition, 172 pages. The growth has been in the number of listings, the increase in advertisers and the addition of new material. The first edition of *Entoma* contained 34 pages of advertising supplied by 50 firms, the second edition 42 pages of advertising by 75 firms, and the third edition 47¾ pages of advertising by 75 firms. Most of the advertising firms are well pleased with *Entoma* and several have written in asking about the next edition.

Financially, *Entoma* has been a success. The receipts for the third edition of *Entoma* have been $2,585.21 (not including $219.00 still due November 1, 1939) and the expenses $1,170.02. This leaves a balance of $1,415.19.

Up to November 1, 1939, the following copies of the third edition of *Entoma* were sent out. To members of the American Association of Economic Entomologists and to the members of the Eastern Branch 1,227; to advertisers and agents, 160, sold 219, gratis 27; total 1,633.

The financial statement is appended herewith.

The Committee would appreciate receiving suggestions for the fourth edition which will be gotten out in 1941. These suggestions should be in writing and sent to the Chairman.

A. E. BADERTSCHER
NEELY TURNER
J. L. HORSFALL
R. C. ROARK
H. B. WEISS
C. C. HAMILTON, *Chairman*

FINANCIAL STATEMENT OF *ENTOMA*

NOVEMBER 1, 1938, TO NOVEMBER 1, 1939

This report is independent of the copies of the Third Edition of *Entoma* sent out to members of the American Association of Economic Entomologists or to members of the Eastern Branch.

Copies of *Entoma* sent out gratis:				
1935 Edition		0		
1937 Edition		47		
1939 Edition		27		
Cash Receipts				
Copies of *Entoma* sold:				
1st Edition	0			
2nd Edition @ 50¢ each	27	$ 13.50		
2nd Edition @ 75¢ each	31	23.25		
2nd Edition @ $1.00 each	4	4.00		
3rd Edition @ 75¢ each	55	41.25		
3rd Edition @ $1.00 each	136	136.00		
Postage received in cash		.06		
Payment received for *Entoma* sold previous to 11-11-38		8.25		
			226.31	
Advertisements and Listings 3rd Edition				
14 ¼-page ads—13 paid		194.25		
33 ½-page ads—33 paid		993.00		
1 ¾-page ad—1 paid		35.00		
27 1-page ads—23 paid		1,115.65		
40 Listings—36 paid		36.00		
1,000 Reprints—E. L. Bruce Co.		5.00		
1,000 Reprints—Giro Associates Inc.		7.00	2,325.90	
				2,552.21
Receipts in Stamps for Entoma				
Copies 1st Edition	0			
Copies 2nd Edition @ 25¢ each	1	.25		
Copies 2nd Edition @ 50¢ each	3	1.50		
Copies 2nd Edition @ 75¢ each	1	.75		
Copies 3rd Edition @ 75¢ each	3	2.25		
Copies 3rd Edition @ $1.00 each	2	2.00		6.75

Cash Due				
For *Entoma:*				
Copies 2nd Edition @ 50¢ each	2	1.00		
Copies 2nd Edition @ 75¢ each	5	3.75		
Copies 3rd Edition @ 75¢ each	10	7.50		
Copies 3rd Edition @ $1.00 each	14	14.00		
			26.25	
Advertisements and Listings 3rd Edition				
1 ½-page advertisement		815.00		
4—1-page advertisements		200.00		
4—Listings		4.00	219.00	
				245.25
Cash Statement				
Balance from 11-1-39		33.06		
Received from Mr. Weiss for Stamps		191.70		
				224.76
Grand Total				$3,028.97
Disbursements				
Cash to Mr. Weiss				$2,435.85
Cash for stamps		$214.70		
Misc. expenses		2.78		
Telegraph and Telephone		2.19		
				219.67
Local Bills paid:				
Stenographic services		26.50		
Stenographic services		51.45		
Expense, trip to N. Y. Eastern Branch meeting 10-28-39		3.00		
Bank Commissions		.55		
				81.50
Cash on hand		.70		
Balance at bank		39.25		
				39.95
Stamps used, received for *Entoma*				6.75
Total Disbursements				$2,783.72
Cash due on *Entoma* sales			$26.25	
Cash due on Advertisements and Listings			219.00	
				245.25
Grand Total				$3,028.97
Receipts				
1939 *Entoma* Sales				
Cash		$226.31		
Stamps		6.75		
Due		26.25		
			$259.31	
1939 *Entoma* Ads				
Cash		2,325.09		
Due		219.00		
			2,544.90	
				$2,804.21
Expenditures				
Stamps		214.70		
Stationery		26.50		
Printer		730.00		
Clerical		190.30		
Misc. expenses		8.52		
				$1,170.02

REPORT OF AUDITING COMMITTEE

We have examined the financial statement and books of Harry B. Weiss, Secretary-Treasurer of the Eastern Branch of the American Association of Economic Entomologists, for the year 1939, and find them correct.

L. A. STEARNS
T. L. GUYTON

November 17, 1939.

REPORT OF COMMITTEE ON RESOLUTIONS

Resolved, That the members of the Eastern Branch Branch of the American Association of Economic Entomologists have suffered a great loss in the death of a gifted scientist and highly appreciated friend, Dr. Wilton Everitt Britton, late State Entomologist of Connecticut, and that we therefore place on record our deep appreciation of a long and most useful life; and

Be It Further Resolved, That the Secretary send a copy of this resolution to the family of the late Doctor Britton.

Resolved, That the thanks of the members be herewith tendered to our Secretary, H. B. Weiss, for the excellent arrangements made by him for this meeting.

Resolved, That the thanks of this organization be tendered by the Chairman to the management of the Hotel New Yorker for the very satisfactory facilities and services furnished by the management for this meeting.

Resolved, That the thanks and appreciation of the members are due and are herewith extended to our Committee on Finance, for their very excellent work in connection with the issuance of *Entoma*.

Resolved, That a special committee be appointed by the Chairman, to consist of not less than three members, to give full and careful consideration to the present requirements as to annual dues and membership classification, and to present a report at the next annual meeting, with such recommendations as such committee may deem appropriate. In its consideration of these matters, the said committee is authorized to consult the membership of the Eastern Branch, and other Branches, as well as the American Association of Economic Entomologists.

Resolved, That a summer field meeting of the Branch be held during 1940, at such time and place as may be determined by the Chairman, Vice Chairman and Secretary, jointly.

C. H. HADLEY
CHARLES E. PALM

November 17, 1939.

REPORT OF COMMITTEE ON NOMINATIONS

Your Committee on Nominations proposes the following persons to serve as the officers of the Eastern Branch of the American Association of Economic Entomologists for the coming year, 1940:

For Chairman, W. H. White
For Vice-Chairman, J. L. Horsfall

HARRY F. DIETZ, *Chairman*
W. E. BLAUVELT
E. R. SASSCER

November 17, 1939.

The following members and guests registered during the meetings:

Allen, H. W.
Alsterlund, J. F.
Annand, P. N.
Anderson, Lauren D.
Anderson, Oscar N.
Appelbaum, Monroe C. I.
Badertscher, A. E.
Bailey, Harold L.
Baker, Walter C.
Bartlett, Irene L.
Beard, R. L.
Beckwith, Charles S.
Beinhart, E. G.
Benmosche, Jack
Blanton, F. S.
Blauvelt, W. E.
Bohman, F. E.
Brann, James L., Jr.
Brody, Philip H.
Bromley, S. W.
Brunson, M. H.
Buchanan, W. D.
Buchholz, A. B.
Buchholz, Lewis W.
Buettner, William O.
Burgess, A. F.
Burgess, Emory D.
Carruth, L. A.
Chapman, Paul J.
Cissel, P. Calvert
Clement, R. L.
Collins, C. W.
Collins, Donald L.
Connola, Donald P.
Cory, Ernest N.
Crawford, J. C.
Dachs, M. H.
Daniel, D. M.
Darley, Merrill M.
Dean, R. W.
Dewson, I. B.
Dietz, Harry F.
Ditman, L. P.
Dobroscky, Irene D.
Dohanian, S. M.
Donohoe, Heber C.
Driggers, B. F.
Drucker, Irving H.
Dutky, Samson R.
Dye, H. W.
Eastman, P. M.
Eaton, N. A.
Elliott, G. R.
Eldredge, W. B.
Evans, J. A.
Feinus, David
Ferguson, William C.
Fellton, Herman L.
Felt, E. P.
Filmer, Robert S.
Fleming, D. M.
Fleming, Walter E.
Fremed, N. L.
French, G. T.
Friend, Roger B.
Gambrell, F. L.
Garman, Philip
Geissler, G. H.
Gemmell, Louis G.
Ginsburg, J. M.
Glasgow, Hugh
Goodhue, Lyle D.
Graham, C.
Granett, Philip
Guggenheim, S.
Guill, J. H.
Guy, H. G.
Guyton, Thomas L.
Haar, Frederic M.
Hadley, C. H.
Haller, B.
Hamilton, Donald W.
Hamilton, C. C.
Hammer, O. H.
Harman, S. W.
Hartzell, Albert
Haude, W. J.
Hawkins, John H.
Headlee, T. J.
Heal, R.
Heap, W. R.
Hess, Jacques J.
Hoffman, Clarence H.
Horsfall, J. L.
Hynak, Joseph
Huckett, H. C.
James, W. S.
Jaynes, H. A.
Jennings, E. R.
Jobbins, Daniel M.
Johnson, J. Peter
Jones, Thomas H.
Josephson, I. H.
Joyce, R. D.
Kelsheimer, E. G.
King, J. L.
Kisliuk, Max, Jr.
Klatte, John Wm.
Koslau, Harry
Langford, Geo. S.
Lathrop, F. H.
Ledurth, Thomas J.
Leonard, M. D.
Levine, Ira A.
MacCreary, Donald
Maughan, Frank B.
Mayer, Philip, Jr.
McConnell, H. S.
Medoff, John K.
Mendall, Seaton C.
Myers, Herbert
Meyer, Martin F.
Morrill, Austin W., Jr.
Mundinger, F. G.
Norris, John
Nottingham, J. O.
O'Neill, W. J.
Opitz, Charles F.
Parker, Lawrence B.
Patterson, N. A.
Payne, Nellie M.
Peairs, L. M.
Pepper, Bailey B.
Philipp, Leopold
Pierpont, Roger L.
Poos, F. W.
Pyenson, Louis
Ramsay, M. J.
Ratner, W. B.
Rawlins, W. A.
Reiner, William
Ressler, I. L.
Rex, E. G.
Richardson, H. H.
Rohwer, S. A.
Rosen, S. S.
Rosenthal, Max
Sameth, H. G. I.
Sameth, J. Edwin
Sanders, George E.
Sasscer, E. R.
Schiff, Carl J.
Schurminer, Y. Chester
Schwardt, H. H.
Sessler, S.
Sheffield, H. F.
Sherman, R. W.
Silber, M.
Smith, Charles M.
Smith, George R.
Smith, J. VanVelsor
Snyder, Fred M.
Soraci, F. A.
Stadholz, B.
Stearns, L. A.
Steiner, Harold M.
Stene, A. E.
Sullivan, W. N.
Thompson, F. M., Jr.
Tomlinson, W. E., Jr.

Townsend, J. F.
Turner, Neely
Van Dine, D. L.
Vogel, Lothar
Vollertsen, B. H.
Walden, B. H.
Walker, Harry G.
Watkins, T. C.
Webber, R. T.
Weed, Alfred
Weening, Bernard E.
Weirich, Clarence L.
Weiland, G. S.
Weiss, Harry B.
Westcott, Cynthia
Whelan, Helena A.
Whitcomb, W. D.
White, Ralph T.
White, W. H.
Whitten, Russell R.
Whittington, F. B.
Wilcoxon, Frank
Willey, C. R.
Wolfenbarger, D. O.
Worthley, H. N.
Zappe, M. P.

PROCEEDINGS OF THE TWENTY-FOURTH ANNUAL MEETING

PACIFIC SLOPE BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Stanford University, Palo Alto, Calif., June 27–29, 1939

A general account of the meetings of the Branch has been published in the February number of the *Journal*.

In the business sessions, reports of committees appointed by Chairman R. H. Smith were received and are herewith presented. The officers nominated by the Nominating Committee were declared elected.

REPORT OF THE RESOLUTIONS COMMITTEE

Whereas the Pacific Slope Branch of the American Association of Economic Entomologists has enjoyed an interesting and profitable session on the campus of the Stanford University at Palo Alto, California on June 27–28–29–1939, and whereas the success of this convention was made possible by efforts of various officers, committee men and exhibitors. Therefore the resolutions committee offers the following resolutions:

Be it Resolved that this Association extends to Prof. R. W. Doane and the Stanford University our appreciations and thanks for the accommodations and hospitality extended our members during our meetings on the campus.

Further that the Association express its thanks to all the various manufacturing companies and other exhibitors of pest control equipment and supplies for their valuable exhibits and demonstrations and that such thanks be further expressed by letter from our secretary to these companies.

Further that we express our appreciation to the various institutions and laboratories for their exhibits of insects, charts, teaching materials, manuals, and books, and chemicals used for insecticides.

Further that we express our appreciation to our retiring chairman Dr. R. H. Smith and his committees for their efforts and the marked success of these meetings.

Whereas a considerable portion of the membership of the American Association of Economic Entomologists resides in the Western half of North America *and whereas* there has never been a national winter meeting held west of the Rocky Mountains.

Therefore *Be it Resolved* that the Pacific Slope Branch of this association request the serious consideration of the officials of the parent Association to the holding of such a meeting on the Pacific Coast in the near future.— E. O. ESSIG, T. D. URBAHNS, J. C. ELMORE, *Resolutions Committee.*

REPORT OF THE TREASURER

Balance on hand June 23, 1939	$20.03
Receipts:	
Refund from parent Association for 1938 meeting	16.32
Interest	.32
Collection taken at meeting	27.13
	$63.80
Disbursements:	
Express	1.08
Preliminary announcement	10.01
Envelopes	11.16
Mimeographing	9.35
Preparing mailing list, stenciling, addressing, and mailing service	11.90
Bracket screws for exhibits	.51
420 stamps	6.30
Mimeographing lists of chemicals used for insecticide exhibit	9.40
	$59.31
Balance	4.49
	$63.80

We have checked the treasurer's accounts and found them O.K. A. W. MORRILL, PAUL JONES, *Auditing Committee.*

REPORT OF THE NOMINATING COMMITTEE

The following names were proposed for the offices indicated:

Chairman	B. G. Thompson
Vice-chairman	H. L. Seamans
Secretary-Treasurer	Roy E. Campbell

A. F. SWAIN, G. F. KNOWLTON, DON C. MOTE, *Nominating Committee.*

The following members and guests registered during the meetings:

Armitage, H. M.
Borden, A. D.
Bowen, M. F.
Boyce, A. M.
Brown, Gary T.
Buckner, R. P.
Burke, H. E.
Campbell, R. E.
Chiu, S. F.
Cooley, C. E.
Cody, L. R.
Cook, W. C.
Craig, Roderick
Cressman, A. W.
Doane, R. W.
Durham, Wallace
Eaton, Charles B.
Ebeling, Walter
Eckert, J. E.
Elmore, J. C.
Essig, E. O.
Fenton, Alfred

Ferris, G. F.
Flanders, S. E.
Flebut, A. J.
Good, N. E.
Grady, H. J.
Henderson, Charles F.
Herms, Wm. B.
Hoskins, W. M.
Howland, Adelbert F.
Jones, Paul R.
Kagy, J. Franklin
Kaloostian, G. H.
Kinsley, C. H.
Kirkpatrick, A. E.
Kitchel, Robt. L.
Knowlton, G. F.
Lange, W. Harry
Lindgren, David L.
Linsley, E. Gorton
Lindquist, A. W.
Maxwell, Kenneth E.
McGregor, E. A.
McLane, F. B.
Michelbacher, R. E.
Morrill, A. W.
Mote, Don C.
Munger, Francis
Parker, William B.
Persing, C. O.
Penny, D. D.
Quayle, H. J.
Rohwer, S. A.
Sasscer, E. R.
Salman, K. A.
Simmons, Perez
Smith, Leslie M.
Southward, T. D.
Strand, T. P.
Steinweden, John B.
Swain, A. F.
Thompson, B. G.
Todd, Frank E.
Upholt, Wm. M.
Urbahns, T. D.
Van Duzee, E. P.
Van Leeuwen, E. R.
Wampler, E. A.
Wehrle, L. P.
Westgate, Warren A.
Wilson, C. C.
Wilson, Kenneth F.
Woglum, R. S.
York, G. F.
Van Dyke, Edwin C.

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JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 33 June 1940 No. 3

Biological Control of the Codling Moth and the Oriental Fruit Moth

J. E. Webb, Jr. and C. H. Alden, *Georgia Department of Entomology, Cornelia*

During a ten year period, 1930 to 1939 inclusive, the Georgia Department of Entomology has operated a laboratory for study and advancement in biological control of the codling moth, *Carpocapsa pomonella L.*, and the oriental fruit moth, *Grapholitha molesta* Busck. The greater portion of time and effort have been devoted to mass production of, and experimental work with *Trichogramma minutum* Riley as a supplemental control for these two insects. However, considerable work has been done with the fruit moth larval parasite *Macrocentrus ancylivorus* Rohwer. The laboratory host used in the mass production of *T. minutum* is the angoumois grain moth *Sitotroga cerealella* Oliver in the egg stage, and the host for *M. ancylivorus* is the strawberry leaf roller *Ancylis comptana* Fröhlich.

Sitotroga Production Methods.—The two grain moth breeding rooms are each 15 ft. by 15 ft. by 7½ ft. and each is equipped with seven breeding cabinets* which hold about one and one-half bushels of wheat per cabinet. These cabinets as shown in figure 1 are 27½ by 29½ by 21½ inches, outside dimensions, with 14 inch legs, and are equipped with four trap cans in the upper corners.

The wheat is first fumigated with carbon bisulphide in tight metal drums where it is kept until needed. When a new cabinet is to be started the wheat is heat treated in water at 70 degrees Centigrade and placed in fourteen vertical screened frames which are suspended from the top of the unit. Four cabinets in one room have each been equipped with a 40 watt light bulb in the top (entering through a funnel soldered to the center of the top). The moths apparently show a negative phototropic response since many more were taken from the trap cans on the lighted than on the unlighted units in the same room.

Each room is equipped with an electric heating unit and a system of fans which blow cool moist air from the basement when necessary to cool off the room in hot weather. The room temperature is controlled by thermostats set at about 80 degrees Fahrenheit. Once or twice each day

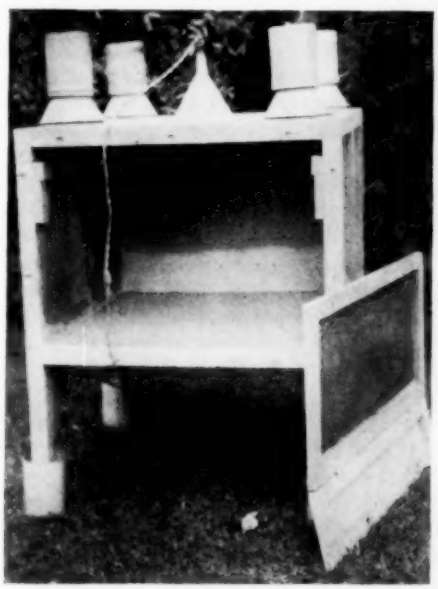

Fig. 1. Angoumois grain moth breeding cabinet with light in top.

the rooms are sprayed with water and the wheat is kept moistened by spraying water through the screened sides of the cabinets. This watering also drives the moths upward and into the cans. A relative humidity of about 70 per cent as optimum for oviposition and moth production is maintained. The legs of the cabinets are

* Plans for building these cabinets were obtained from Dr. Herbert Spencer, of the U. S. Bureau of Entomology and Plant Quarantine.

placed in cans of oil to keep out ants, mites and various other pests. Once every two weeks dead moths and water are removed from the floor of the units in order to keep down obnoxious odors, breeding of mites and various other scavengers.

Twice each day the moths are collected and several thousand are placed in each 6 by 8 inch glass battery jar for oviposition. Each morning the eggs are collected by loosening them from the bottom of the jars with a camel-hair brush, then shaking through the 20-mesh screen jar tops. A 10-inch electric fan on the opposite side of the oviposition table carries off the greater part of the moth scales, broken legs, etc., leaving the partially cleaned eggs on a 3 by 3 foot piece of heavy wrapping paper. Cleaning of the eggs is completed by repeated sifting and blowing away the dust particles by mouth. Over a million and a half eggs have been produced in one day.

By means of *Cico* liquid paste the eggs are stuck onto cardboard squares holding about 18,000 eggs each. The squares are divided into six smaller sections which are readily clipped apart with scissors. Each section makes a convenient size colony of parasites to be hung in one tree.

Each cabinet is stocked with about two million grain moth eggs and will produce large numbers of moths for about three months. After that period, the cabinet is cleaned out, repainted, and restocked with wheat and moth eggs. By starting the majority of the cabinets in early spring, it is possible to produce large numbers of eggs during May, June, July and August, when parasites are needed for effective control work. Nearly 164,000,000 eggs were produced in 1939.

Trichogramma minutum PRODUCTION, DISTRIBUTION, AND RECOVERY.—The cards of fresh eggs are exposed in closed, carefully matched petri dishes, several to each two-thirds of a card of newly emerged parasites. One card is introduced into each dish about every three hours during the first day until four cards are parasitized. On the morning of the second day, two more cards are exposed in each dish at three hour intervals. This procedure results in six well parasitized cards per dish of a two-thirds card of a parent stock, which gives a nine fold reproduction. The laboratory turnover is completed every seven days if the temperature is kept at about 80 degrees. The parasitized cards remain in the dishes until they are four days old. They are then mailed, four cards per box, to peach and apple growers. Only enough cards are withheld for the next turnover. Enclosed in each box mailed out is a mimeographed sheet of directions for putting out the parasites and a quantity of fine copper wire for hanging up the card sections. When suspended from a limb by the small wire, the parasitized eggs are inaccessible to predacious insects. The grower cuts the card into sections which are hung, one per tree, with 8 inch lengths of wire. These are distributed over the orchard usually in locations of heaviest insect infestation. Shipments are so timed that if the parasites are put out on the day received they will begin emerging in from one to four days, depending on temperature and promptness of delivery.

The petri dishes used for reproduction are placed, one deep, on racks arranged to face the window so that they receive as much daylight as possible. One rack is covered by glass and built onto a thermostatically controlled heating unit used for parasite turnover in cold weather. This work is done in a small parasite breeding room, equipped with a 10 inch electric fan set in the wall near the ceiling. The fan is operated in hot weather to produce a draft of cool moist air from the basement, the air being pulled through a hole 12 inches square in the center of the floor. During the hottest weather the temperature, thus controlled, never exceeds 83 degrees F. A small piece of raisin is stuck in the upper edge of each dish to furnish moisture and food for the adult parasites.

As shown in table 1 the full number of parasites colonized from 1929 to 1939 inclusive for codling moth and fruit moth control was 310,991,000. In addition to this number, 19,263,000 were colonized for control of pecan, truck and cotton insects, making a total of 330,254,000 colonized.

The summary given in table 2 shows that out of 37,057 codling moth eggs collected from 1930 to 1939, an average of 56.2 per cent was parasitized by *T. minutum*. The highest for any one collection was 97.6 per cent in 1933 while the highest average for all eggs collected in any one year was 77.6 per cent in 1932.

As shown in table 3, 2,101 Oriental fruit

Table 1.—Summary of *Trichogramma minutum* colonized in Georgia from 1929 to 1939.

Year	Number of Parasites Colonized		
	Apples*	Peaches	Total
1929	315,000	20,000	335,000
1930	1,673,000	1,828,000	3,501,000
1931	1,750,000	750,000	2,500,000
1932	4,785,000	2,355,000	7,140,000
1933	19,698,000	7,578,000	27,276,000
1934	1,574,000	324,000	1,898,000
1935	23,595,000	20,546,000	44,141,000
1936	17,537,000	21,394,000	38,931,000
1937	12,597,000	23,028,000	35,625,000
1938	17,569,000	38,196,000	55,765,000
1939	33,839,000	60,040,000	93,879,000
Total	134,932,000	176,059,000	310,991,000

* From 1930 to 1935 inclusive, several million parasites were furnished by Dr. Herbert Spencer of the U. S. Bureau of Entomology and Plant Quarantine Parasite Laboratory, of Albany, Georgia, and these were used in a cooperative experiment with the state on codling moth biological control.

moth eggs were collected from 1930 to 1939, of which 36.3 per cent was parasitized. The highest parasitism of any one collection was 85.7 per cent in 1930 and 1938, while the highest percentage for all eggs collected in any one year was 47.3 per cent in 1930.

Table 4 gives the harvest results in an experimental Elberta orchard in which 2,000 fruits were scored each year from 1932 to 1939 inclusive. An almost continuous decrease in fruit moth infestation has occurred during that period. The infestation in 1932 was 23.9 per cent and has been reduced to 0.3 per cent in 1939. *T. minutum* have been colonized in this orchard each year and one or more colonies of *Macrocentrus ancylivorus* have been liberated since 1932. That *T. minutum* are highly effective against the eggs of late brood fruit moths was demonstrated by an examination of 145 fresh and parasitized eggs collected from three Elberta orchards in August, 1938, which had 81.4 per cent of the eggs parasitized.

Table 2.—Summary of codling moth eggs parasitized by *Trichogramma minutum* in Georgia.

Year	Total Eggs Collected	Per Cent Parasitized			Per Cent Unparasitized
		Highest	Lowest	Average	
1930	1,382	79.4	54.3	70.4	29.6
1931	4,069	84.6	40.5	75.7	24.3
1932	11,091	94.2	57.6	77.6	22.4
1933	4,223	97.6	9.1	76.1	23.9
1934	1,850	76.2	0.0	58.6	41.4
1935	7,017	66.0	0.0	42.9	57.1
1936	2,000	48.2	6.7	26.2	73.8
1937	2,542	34.3	0.0	24.0	76.0
1938	1,536	60.6	23.2	51.2	48.8
1939	1,347	90.5	0.0	66.6	33.4
Total	37,057	97.6	0.0	56.2	43.8

Table 3.—Summary of Oriental fruit moth egg parasitism by *Trichogramma minutum* in Georgia.

Year	Total Eggs		Per Cent Parasitized		Per Cent Unparasitized
	Collected	Parasitized	Maximum	Average	
1930	383	181	85.7	47.3	52.7
1931	515	81	43.5	15.7	84.3
1932	169	61	45.3	36.1	63.9
1938	862	395	85.7	45.8	54.2
1939	172	44	37.4	25.6	74.4
Total	2,101	762	85.7	36.3	63.7

DIFFICULTIES IN PRODUCTION OF *Sitotroga cerealella*.—All wheat is carefully selected, fumigated and sterilized to insure freedom from all insect life before being placed in the breeding rooms. Despite every precaution the moth population is occasionally wiped out by an infestation of the hymenopterous parasite *Habrocytus cerealella* Ashm. or the mite *Pediculoides ventricosus* Newport. Although other laboratories have been seriously hampered by this mite, it has never been a factor at the Cornelia laboratory; but on several occasions the breeding rooms have been invaded by *H. cerealella*. It has never reached destructive proportions, however, until the end of the season. Other pests which may be classed as nuisances, rather than hazards are the rice weevil, the cadelle, the red rust flour beetle, the saw-toothed grain beetle, ants and spiders.

CONTROLLING *Habrocytus cerealella* OUTBREAKS.—The procedure used to rid the laboratory of this parasite is to select two or three of the highest producing cabinets and move them to another building several blocks away where the collection of the moths is continued in order to get eggs to stock new cages. After removing the stock of *Trichogramma minutum* and other necessary articles from the building, the whole laboratory is fumigated with hydrocyanic acid gas for at least 48 hours. Immediately afterward

Table 4.—Oriental fruit moth infestation at harvest in Elberta peaches from experimental orchard 1932–1939.

Fruit Moths from 2,000 Peaches Scored in Year							
1932	1933	1934	1935	1936	1937	1938	1939
23.9%	10.9%	11.2%	0.3%	0.3%	2.5%	0.5%	0.3%

a thorough cleanup is effected and all infested wheat is taken to the dumping ground a considerable distance away. No grain moths or exposed grain are kept in the laboratory for at least a month thereafter in order that any stray *H. cerealella* will perish. In the meantime, two or three new wheat cabinets are being stocked with fresh moth eggs which have been dipped in carbon bisulphide. These new units are kept in another building away from the laboratory and the building in which the moth producing units are stored. The carbon bisulphide will kill any larvae or mites but does not injure the fertility of the grain moth eggs. When a month or more has passed, the new cabinets are brought into the laboratory and additional ones started from time to time as needed.

PRODUCTION AND COLONIZATION OF *Macrocentrus ancylivorus*.—The Cornelia laboratory, in cooperation with Dr. H. W. Allen, of the U. S. Bureau of Entomology and Plant Quarantine has made available a large number of colonies of *M. ancylivorus* for colonization in Georgia peach orchards for the control of the fruit moth. The first colonizations were made in 1930 and additional ones almost every year since that time. Special emphasis was given this project in 1938 and 1939 when 162 colonies of about 200 parasites each were liberated. The greater numbers of these parasites have been reared and collected in a special dark room at the Cornelia laboratory. The parasites were obtained from strawberry leaf roller material shipped from New Jersey. These shipments were made possible by the courtesy of Dr. Allen who has also furnished a number of colonies of adult parasites ready for liberation. During 1938 and 1939 several thousand *M. ancylivorus* have been produced in a special outdoor strawberry leaf roller cage. Altogether about 40,000 specimens have been colonized throughout the state.

METHODS OF HANDLING *Macrocentrus ancylivorus*.—The strawberry leaves containing parasitized leaf rollers are spread out on a series of hardware cloth bottom trays in the breeding room. The leaves are stirred occasionally to prevent moulding until dry. During the period of parasite emergence, the desired humidity is maintained by occasionally spraying with water. All sides of the room are black except one white side to which the moths and parasites are attracted and from which they are collected by means of a vacuum cleaner. This cleaner has a special offset which sucks the parasites into a one by five inch piece of glass tubing having a medium coarse mesh cloth bottom. Males and females are counted and collected separately, putting about 100 per vial, and are then transferred, 100 of each sex, to individual carrying cages.* These are wooden frame cages $3\frac{1}{2}$ by 8 by $3\frac{1}{2}$ inches, with fine mesh cloth top and bottom to permit free air circulation. As soon as each cage receives its colony of parasites, it is wrapped in moist absorbent cotton and several thicknesses of paper and held in a refrigerator until carried to an orchard where the insects are liberated through the removable sliding top of the cage.

RECOVERY OF LARVAL PARASITES.—Almost every year since 1930, peach twigs infested with fruit moth larvae have been collected from orchards where *M. ancylivorus* have been colonized. The twigs are carried back to the laboratory to determine the percentage of parasitism by rearing the larvae to maturity. Of 3,450 twigs collected during the ten-year period, 1,340 total emergencies have been obtained, of which 385 or 28.7 per cent have been *M. ancylivorus*. In addition to these, 11 specimens of other parasites have been obtained, making a total average of 29.6 per cent larval parasitism. The highest percentage for any one twig collection was 100 per cent in 1930 while the highest average for any one year was 80.2 per cent in 1937.

Larvae of the codling moth are parasitized by several native species of parasites. Of 2,593 total emergences recorded from first, second and third brood larvae during the years 1936 to 1939 inclusive, 496 or an average of 19.1 per cent were parasites. *Ascogaster carpocapsae* Viereck and its hyper-parasite *Perilampus* sp. represented nearly 95 per cent of the total parasite recovery. The hyper-parasites represent about 25 per cent of the above figure. Other species recorded are *Pristomerus agalis* Cresson, *Phanerotoma tibialis* Hald., and *Calliephialtes grapholithae* Cresson, all of which are of minor importance.

A NEW ICE BOX FOR TRANSPORTING

* Plans for this cage were obtained from the Federal Parasite Laboratory at Moorestown, N. J.

LIVE INSECTS.—In handling large numbers of *Macrocentrus*, it is often necessary to make over-night trips which require cold storage facilities for the parasites until time of release. This problem has been met by a special ice box (Fig. 2) designed and built to hold nine of the field carrying cages. The outside dimensions of the box are 17 by 20 by 18 inches. It is constructed of pine boards three-eighths inch thick, there being two walls three-fourths inch apart, between which fine sawdust is packed. The inner wall is lined with sheet metal made water tight with solder. A water tight sheet metal box for holding the parasites fits in the center of the larger box so that a two and one-half inch space for chipped ice is left on all sides. The metal box is fitted with a metal cover having flanges to prevent water from entering the top. The ice box is fitted with a sturdy handle on either end and a sawdust packed hinged top with a stay-open catch. A short piece of half-inch iron pipe fitted in a lower corner serves to drain away the water if desired. When packed with about 25 pounds of ice, the box will maintain a satisfactory temperature for 36 hours or more in summer weather. It can as readily be used for transporting many other types of animal life in cold storage and fits easily on the floor between the seats of a coach or sedan type automobile, or in the rear compartment trunk.

SUMMARY.—More than three hundred million *Trichogramma minutum* have been colonized in commercial peach and apple orchards since 1930. Over a million and a half laboratory host eggs, *Sitotroga cerealella*, have been produced in one day with the wheat cabinets. Of 37,057 codling moth eggs collected, 56.2 per cent were parasitized, and of 2,101 fruit moth eggs collected, 36.3 per cent were parasitized by *T. minutum*. About 40,000 *Macrocentrus ancylivorus* have been colonized in commercial peach orchards for fruit moth control. Of 3,450 fruit moth infested twigs collected in these colonized orchards, 1,340 total emergences were obtained with an average of 29.6 per cent parasitism, mostly *M. ancylivorus*. Of 2,593 total emergences from codling moth larvae, 19.1 per cent were parasites, mostly *Ascogaster carpocapsae*. It is estimated that the egg and larval parasites of the fruit moth destroy 55.2 per cent† of its total population and those parasitizing the eggs and larvae of the codling moth destroy 64.6 per cent† of its population. The scoring of two thousand harvested fruits each year, from 1932 to 1939 inclusive, in an experimental Elberta peach orchard where both *T. minutum* and *M. ancylivorus* have been colonized, shows an almost continuous decline of fruit moth infestation. Other data included are: combating *Hal rocytus cerealella* and other pests of the grain moth breeding rooms; the production, colonization and method of handling *Macrocentrus;* and a new ice box for transporting live insect material.—1-6-40.

FIG. 2. New icebox for transporting live insects.

† This figure was derived by multiplying the per cent larval parasitism by the figure resulting when the per cent egg parasitism is subtracted from 100 as total population, then adding the result to the per cent egg parasitism.

PEAR PSYLLA infestations having been found in Kootenai County, Idaho, and in Spokane County, Wash., quarantines were established by these States in March 1940, which prohibit the movement of pear or quince trees or parts, from the infested counties, and require that the fruits shall be prepared and handled in such a way as to prevent carrying infestation. Packing boxes, containers, props, ladders, rough lumber, firewood, leaf mold, and compost, from the infested properties, as well as vegetables, are also placed under regulation designed to eliminate danger of spread.

Codling Moth Flight Habits and Their Influence on Results of Experiments

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Fifty years ago C. P. Gillette (1889) called attention to the influence that codling moth migration might have on experimental data, and stated that nothing like correct results could be expected in figuring out the protection given by various spray treatments except in an area where the insect is single brooded. He suggested that, in order to get correct results, separate records should be made of the injury caused by the two broods; otherwise the results would be vitiated by the large number of eggs that would be laid upon the sprayed trees by moths flying in from the unsprayed check trees, and also by a decrease in the number of eggs that would be laid on the check trees because of the great numbres of larvae of the first brood destroyed upon the treated trees in their vicinity. Following experiments conducted in 1915, Siegler & Plank (1921) concluded that the codling moth was a nonmigratory species except for short local flights, but stated that the moths had strength to fly in a continuous flight, unaided by the wind, for a distance of at least one-half mile. It seems to have been the opinion of many other workers that the codling moth remains close to its point of emergence. Evidence sometimes offered is that the influence of open packing sheds is not evident beyond a very few tree rows and that certain trees or areas in the orchard are, year after year, more heavily infested than their neighbors. Very little definite information, however, seems to be available.

During the course of investigations on the codling moth in southern Indiana considerable information on the flight habits of the adults has been accumulated and is here summarized.*

Release and Recapture of Moths.—During the years from 1934 to 1938, inclusive, approximately 10,000 newly emerged codling moth adults were marked by the method used by Steiner & Yetter (1933) for the oriental fruit moth, and liberated in or near areas containing experimental bait solutions. Most of the baited areas ranged from 10 to 15 acres in size, although additional scattered traps were generally located in other parts of the same orchard. Although the releases were made primarily for the purpose of studying the efficiency of baits, many were made in such a way that distance records could be obtained. In all, 847 such records are available.

The number of flight records each year and the average and maximum distances from the point of release to the point of recovery for liberations made in baited areas and outside of trapped areas among unbaited trees are given in tables 1 and 2.

Table 1.—Distances traveled by marked adult codling moths after their release within bait-trap areas.

Year	Flight Records, Number	Distance from Point of Release to Point of Recovery (Feet)	
		Average	Maximum
1934	211	232	2,079
1935	322	188	1,710
1936	77	204	1,622
1937	73	127	663
1938	61	219	760

Table 2.—Distances traveled by marked adult codling moths after their release outside of baited areas.

Year	Flight Records, Number	Distance from Point of Release to Point of Recovery (Feet)		Average Distance Traveled Over Bait Traps (Feet)
		Average	Maximum	
1934	34	244	941	132
1935	16	634	1,000	274
1936	22	935	2,080	208
1937	4	921	1,178	173
1938	27	656	1,238	306

Trap Captures.—Moths recovered from releases made within baited areas flew average distances of 232, 188, 204, 127, and 219 feet, respectively, for the years from 1934 to 1938. Those recaptured following liberation in adjoining unbaited areas flew average distances of 244, 634, 935, 921, and 656 feet for the

* The writer was assisted at various times in these investigations by S. A. Summerland, D. W. Hamilton, R. F. Sazama, B. E. Hodgson, A. J. Ackerman, and several temporary field aides.

same 5 years. The lengths of flights recorded from outside into baited areas were, of course, governed in part by the distance at which the releases were made, and many moths undoubtedly traveled shorter distances without reaching bait traps. On the other hand, the records for recoveries from releases inside the area were usually limited by the size of the area baited. Of 150 moths recaptured from one release made within a 15-acre baited area, 12 were taken in a few scattered traps located in other parts of the same orchard, which contained in all 60 acres. How many others flew out of the 15-acre area but escaped traps in other parts of the orchard is unknown. Most of the long-distance flights were of this type, that is, the moths left baited areas to reappear in traps in some other part of the orchard.

It has been noted each year that flights into the baited area were generally well distributed, that is, some moths flew entirely across before being caught, and the average distance that incoming moths flew over baits after entering the area was greater each year, except in 1934, than that traveled by moths released and recaptured inside. This suggests that many flights are definitely migratory. Therefore, the increased infestation generally present in trees within a few rows of infestation centers may be due largely to a normal filtration or overflowing of moths into the area by means of tree-to-tree flights. Such flights, frequently repeated, could ultimately take a moth a considerable distance from the point where it emerged. At the same time, however, many moths may set off on longer flights which end in all parts of the more lightly infested area.

The possibility has been suggested that the bait traps increase the amount of moth movement. This may be true, in part, of flights to the baited areas from unbaited trees, but many of the flights within and between baited areas were made between trees containing baits of the same formula, suggesting that there are periods in the life of the moth when baits elicit no response, although normal flight may occur. Furthermore, six of 585 moths liberated among unbaited trees in 1938 were recovered from 420 to 638 feet away from the point of release and others at shorter distances, in six unbaited trees that were being treated with a nicotine-lime dust so that, as explained in the following paragraph, population counts could be made.

MOTH POPULATION.—Evidence that mass migration occasionally occurs was secured in 1938 by weekly population counts in two adjacent unsprayed 15-acre areas, one of which was baited. In making these counts, sheets were spread underneath individual trees, which were then treated with a nicotine-lime dust. This caused the moths in the trees to drop to the sheets where they could be gathered and counted. Until July 20 the population averaged higher in the unbaited area. On that date it averaged 19.3 moths per tree in the baited and 30.0 in the unbaited area. One week later the average was 19.7 moths in the baited and only 2.0 per tree in the unbaited area. By the following week the average was 12.5 in the baited and 6.0 per tree in the unbaited area. All the moths found in the latter area during the morning of July 27 appeared to be newly emerged, since their wings were not fully expanded. During the week after July 20 the bait traps were catching more moths in relation to the actual population than at any other time during the season. Those captured included marked moths which had been released near the farthest corners of the unbaited 15-acre block. The average minimum distance traveled from their point of release by these and other moths released in the same area and recaptured in July and August was 656 feet.

The longer flights, of 2,000 feet or more, which have been recorded indicate that the codling moth is capable of flying to all parts of a square 100-acre orchard before completing its egg laying. The recorded flight movement within the baited areas can be considered less than normal, since the distances are limited by the distance to the boundaries of the areas and by the capture of the moths before they have traveled the total normal distance. Thus 200 feet, the approximate average distance traveled by recaptured moths released within baited areas during the past five years, may be taken as a conservative estimate of the average distance away from its point of emergence that a codling moth will normally move.

EFFECTS OF MOTH FLIGHT ON INSECTICIDE TESTS.—It is evident that spray plots of less than 3 acres or with a radius of less than 200 feet may have mi-

gration into their centers from adjacent plots, or from their centers out to adjacent plots. If a third brood occurs the original influence may be extended farther.

Replication of plots is, of course, necessary to equalize the effects of many variables, one of these being the influence of migration. However, no amount of replication can eliminate this influence. Although the unsprayed check referred to by Gillette is now rarely used, moth move-

Table 3.—Influence of codling moth migration in small-plot insecticide tests.

	Total Number of Worms Per Tree		
	July 1	End of Season	Rate of Increase
Lead arsenate			
Latin square	16	321	20 times
Large scale, 130 acres	8	66	8 times
Nicotine bentonite and soybean oil			
Latin square	11	401	36 times
Large scale, 90 acres	8	55	7 times

ment may have just as important an influence on comparisons between different treatments.

Obviously the intensity of the attacks by the second and third broods, in the absence of migration, should be directly influenced by the efficiency of the control treatment against the first brood. It should be apparent also that, of two materials, one may be more effective early in the season and the other later. Since larvae of the later broods are often far more abundant than those of the first, the treatment most effective just before harvest may appear to show the best final results, yet this treatment may have been relatively much less effective against the first brood, and thus responsible for the escape of many early worms and the subsequent heavy attack. Investigations at the Vincennes, Indiana, laboratory for a number of years have shown that lead arsenate, the usual standard of comparison, has this characteristic in most seasons.

For example, in 1937, a latin-square test of three treatments with four trees per replicate was set up for comparison with two of the treatments used in a large-scale commercial test. The results are given in table 3.

In the first-brood period the control with the nicotine treatment was significantly better than that with lead arsenate in the latin-square and equal to it in the large-scale tests. In the latter experiment the initial population difference was unknown, while in the latin-square test it presumably was equalized. A series of samples of fruit taken before and after each spray and infested in the laboratory indicated that the nicotine maintained a significantly higher effectiveness than lead arsenate until the peak of the third-brood larval attack about September 8, a month after the final cover spray.

At the end of the season the advantage built up by the nicotine prior to the third-brood attack was lost in the latin square, where the population increase, largely due to migration, was 36 times as compared with only 7 times in the large area, while with lead arsenate the increase was less than with nicotine in the latin square and only slightly greater in the large area. The small plots thus gave results that were the reverse of those obtained in commercial practice.

It appears likely that migration has as great a leveling effect where 5- or 10-tree replicates are used as where single-tree replicates are employed. It doesn't appear possible to get very far away from its influence with replicates of less than three acres, particularly if any third brood is produced.

It is conceivable that inter-tree movement would be increased above normal in small-plot tests where certain of the treatments are repellent or attractive, or are toxic to adult moths at the time of spraying.

However, the use of 3-acre replicates, because of other disadvantages, would be impracticable in most experimental setups.

It is evident that the results of field experiments in codling moth control obtained by the small-plot method of experimentation, in areas in which the insect passes through two or more broods, must be interpreted with caution. Under many conditions the value of a treatment against the first-brood worms may be largely obscured by an influx of first-brood moths, and erroneous conclusions may be reached. It seems entirely possible, therefore, that by ignoring Dr. Gillette's warning of 50 years ago we may have discarded really

valuable and effective first-brood treatments in the past, simply because migration from other plots or from other parts of the orchard may have wiped out before harvest any sign of their early effectiveness.

Through force of circumstances most workers find it necessary to use small plots for their field experiments with insecticides for the codling moth. Determination of first-brood infestation by examination of the fruit on and under the tree just before the start of second-brood attack may aid in the interpretation of results, and this practice is followed by a few workers. At this point in the season, however, the infestation is usually light, and reliable percentages are difficult to obtain. Practical considerations also place a limit on the extent to which tree counts can be made. The laboratory-field method in use at the Vincennes, Ind., laboratory, whereby determinations are made of the effectiveness of the spray deposits at frequent intervals during the season, is proving very helpful in giving detailed information that cannot be obtained by other types of experiments.

MIGRATION AND SUPPLEMENTARY CONTROLS.—Large experimental plots are absolutely essential if the control test includes treatments such as tree scraping, orchard sanitation and banding, where the treatment effects the greatest reductions in population prior to emergence of spring-brood adults, and where, after the treatments are started, there is one more brood of moths than occurs with spraying tests. For example, in a square 40-acre orchard, in 1937, the hibernating population was previously determined to be 30 per cent greater in the north half. This half was scraped and banded, all trunk cavities were screened and part of the ground debris was removed. At the end of June, counts made on 46 trees showed the average worm population per tree to be 189 in the untreated and 88 in the treated part, or 53.4 per cent less in the latter area. During the remainder of the season, however, the rate of increase in the treated area was 2.4 times and in the untreated only 1.6 times, so that at harvest the difference in favor of the treated area was only 30 per cent. Since the orchard had been sprayed uniformly and there was no evidence of any difference in the parasite and predator population, and the only other nearby orchard was so thoroughly sprayed that it produced less than 1 per cent of wormy fruit, it is apparent that the leveling effect of moth movement even with a light second-brood attack, is capable of affecting control tests as large as 20 acres if two or more inter-brood periods of moth flight occur between the time of application of the control measure and the determination of the results.

Similar results have occurred in connection with tests of the control value of bait traps, although the more rapid population build-up in a baited area may have been due partly to the attraction of the baits. In 1937, one corner of a 60-acre orchard, comprising approximately 12 acres, was baited with one trap per tree. At the end of June the counts made on 48 trees of three varieties divided between the baited and the adjacent unbaited block of the same size indicated that the worm population was 45.4 per cent less in the baited area. With crops averaging approximately 5,500 apples per tree, the worm populations averaged 1,436 per tree for the unbaited and 784 for the baited areas on June 30. At harvest, however, the average worm population was only 26.3 per cent less in the baited area, where it had increased to 2,696 worms per tree.

SUMMARY.—In 1889 Gillette called attention to the probable effects of inter-tree or inter-plot movement of adult codling moths on experimental results. On the other hand, many workers have felt that moth movement is not great enough to be an important factor. Very little definite evidence, however, has been available.

During the years 1934 to 1938, inclusive, releases of marked moths, outside and inside of baited areas in southern Indiana, and their subsequent recapture in traps or in dusted unbaited trees has proved conclusively that extensive inter-tree and inter-plot movement of moths is normal and common. The average distance traveled away from their points of release was approximately 200 feet in baited areas, where the distance to the outer rows of traps and the stoppage of flight by capture placed a limit on the length of normal flights. Normal movement of 200 feet would be equivalent to a mass migration of all moths from the center to the outside of a 3-acre plot. Individual flights of more than 2,000 feet were recorded, proving the ability of the insect,

if emerging within a 100-acre orchard, to travel to any part of it.

The replication of spray treatments, regardless of whether single-tree or 10-tree replicates are used, will not eliminate the influence of migration. Spray treatments with nicotine bentonite which are highly effective in the first brood but which may weaken shortly before harvest (unless additional sprays are applied), have given control superior to that obtained with lead arsenate when tested on a large enough area so that their effects on the first brood would not be lost, but when tested in small replicated plots the early survivors in the plots sprayed with lead arsenate later provided a population which reinfested the nicotine-treated plots late in the season. Consequently small-plot tests in a two-brood or three-brood area will often show the relative effectiveness of the treatments against only the latest brood, if reliance is placed solely on records from drop and harvest fruit.

Late-season moth migration proved capable of obscuring a large part of the effectiveness of orchard sanitation and banding or of the use of bait traps in tests involving 20-acre and 12-acre plots, respectively. The control obtained after the end of the first-brood period was more than offset by the more rapid build-up of the population in the treated areas late in the season, largely as a result of moth movement.

The evidence suggests that there is a normal leveling off of the population between areas of heavy and of lower density, with movement occurring in both directions proportional to the population. There is also evidence that some moths make long flights and that under favorable conditions some of the population may extend its normal movement to considerable distances, giving the effect of a mass migration.—1-6-40.

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Replacing Cresylic Acid with Tar Oil in the Delayed Dormant Spray on Apple Trees

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Although the superiority of a dormant spray, (3 per cent petroleum oil, 2.5 per cent tar oil) over a delayed dormant spray (3 per cent petroleum oil, 0.5 per cent cresylic acid) in controlling apple aphids in New Jersey has been definitely shown by Ginsburg & Driggers (1938), many growers still find it convenient to start orchard spraying at the delayed dormant period. In addition to the farmers who prefer delayed dormant to dormant spraying, others are often compelled to use the delayed dormant spray on account of either unfavorable weather conditions or inability to cover the entire orchard during the dormant season. For the above and perhaps other reasons, a large percentage of the New Jersey apple growers are applying the delayed dormant spray to control aphids, red mite and scale. Cresylic acid in the delayed dormant spray and tar oil in the dormant spray are the primary toxic agents in killing aphid eggs, while petroleum oil is effective against scale and red mite.

OBJECT OF THE INVESTIGATION.—In view of these facts the present investigation was arranged to determine the minimum concentration of tar oil required to kill eggs of apple aphids in the delayed dormant stage, in place of the 0.5 per cent cresylic acid. The benefits to be derived from such a change would be two-fold. First, the tar oil employed for spraying is considerably cheaper (17 cents per gallon) than is cresylic acid (70 cents per gallon). Second, tar oil can be readily and cheaply emulsified, either separately or combined

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with the petroleum oil, to produce an uniform dispersion in the spray mixture.

METHODS AND MATERIALS.—The experiments were conducted during 1938 and 1939 in a commercial orchard located in Marlton, New Jersey. Delayed dormant sprays comprising 3 per cent petroleum oil and either 0.5 per cent cresylic acid or various concentrations of tar oil, ranging from 0.5 to 2 per cent, were sprayed on the following varieties of apple trees: Starr, Gravenstein, Opalescent, Wealthy, Smokehouse and Williams. The sprays were applied in late March or early April, as warranted by seasonal conditions, employing a Bean power sprayer. Close observations were made on all six varieties for plant injury, and only on Starr, Gravenstein and Opalescent for insect control. From 200 to 500 fruit clusters of each variety in each block were examined for live aphids of all types prior to the pink spray, generally about the middle of April, and for rosy aphids in late May or in early June.

The petroleum oil used was a paraffin distillate, emulsified with soap, of the following specifications: gravity A.P.I. 26–29; viscosity (Saybolt/100 degrees F.) 110; boiling range 650–770 degrees F. The cresylic acid was a partially water-miscible proprietary product containing about 95 per cent tar acids. The tar oil was (unless otherwise indicated) a commercial emulsion containing about 83 per cent high boiling coal-creosote distillates.

EXPERIMENTS IN 1938.—On March 22 four different delayed dormant spray mixtures were applied on blocks of apple trees each containing 4 Starr, 3 Gravenstein, and 2 or more of Wealthy, Williams, and Smokehouse varieties. At the time of spraying the fruit buds on all varieties except Wealthy, were in full delayed dormant stage. The composition of the sprays is given in table 1.

APHIDS.—Since aphid eggs were quite abundant on Starr and Gravenstein and were present only in small numbers on the other varieties, observations on the control of this insect were limited to these two varieties. Counts of live aphids were made April 4 by Ginsburg; April 6 by Driggers; April 11 by O'Neill and April 13 by Ginsburg and Driggers,† giving a total of 500 fruit spurs of each variety in each block. No distinction was made in this series of tests between apple-grain aphid, *Rhopalosiphum prunifoliae* (Fitch), apple aphid, *Aphis pomi* DeG., and rosy apple aphid, *Anuraphis roseus* (Baker), all being counted together. The data, presented in table 1, while showing high aphid control with all four sprays as compared with the checks, indicate slightly lower results for the 0.5 per cent tar oil in one test than for the other three sprays, on each of the two varieties of apple trees.

Table 1.—Effect of tar oil sprays on aphids, applied at the delayed-dormant stage in 1938; 500 fruit spurs of each variety, in each block, were examined.

COMPOSITION OF SPRAY	PER CENT SPURS FREE OF APHIDS		
	Starr	Graven-stein	Average
Petroleum oil 3% Cresylic acid 0.5%	96	100	98
Petroleum oil 3% Tar oil* 0.5%	92	98	95
Petroleum oil 3% Tar oil 1%	98	100	99
Petroleum oil 3% Tar oil 2%	99	100	99.5
Not sprayed	39.4	29	34.2

* A home-made preparation of tar oil containing 20 per cent tar acids.

RED MITE.—While it is a well established fact that 3 per cent petroleum oil, either by itself or in combination with cresylic acid, efficiently controls European red mite, *Paratetranychus pilosus* (C. & F.), as shown by Hamilton (1924), and Headlee & Ginsburg (1929), it was considered advisable to verify the efficiency of the spray combinations used in this investigation for controlling this insect. About 200 leaves from each block of Starr trees were examined, for this arthropod. On the check block 58 live mites were counted, whereas none were found on the sprayed blocks. Apparently the petroleum-tar oil mixture. proved to be as effective as the petroleum-cresylic acid spray.

INJURY TO BUDS.—Injury to advanced fruit buds, primarily where the tips were already showing green, appeared from all spray mixtures within 48 hours after ap-

† The writer takes this opportunity to express his indebtedness to Dr. B. F. Driggers and Mr. W. J. O'Neill for their valuable assistance throughout the experiments.

plication. This injury, while causing no significant damage, was most pronounced on Starrs and Gravenstein, was moderate on Smokehouse and Wealthy and was practically absent on Williams. Distinct retardation in the development of fruit buds on all varieties was produced by the two higher concentrations of tar oil, this being most evident on trees sprayed with

Table 2.—Effect of different concentrations of tar oil in 3 per cent petroleum oil sprays on aphids in 1939; 200 fruit spurs of each variety in each block were examined.

Composition of Spray	Per Cent Spurs Free from Live Aphids				
	Opalescent		Gravenstein		Average of all counts
	All Aphids	Rosy Aphids	All Aphids	Rosy Aphids	
Delayed Dormant					
Cresylic acid 0.5%	98.0	94.5	98.0	93.5	96.0
Tar oil 0.5%	96.5	86.5	97.0	85.0	91.0
Tar oil 0.66%	100.0	98.5	98.5	94.0	97.8
Dormant					
Tar oil 2.5%	100.0	100.0	100.0	100.0	100.0

2 per cent of this chemical. The effect of the retardation in growth was still noticeable as late as April 28, the trees receiving the 2 per cent tar oil spray showing many partially developed and dead lateral fruit buds. No retardation was noticed from sprays containing either 0.5 per cent tar oil or 0.5 per cent cresylic acid.

EXPERIMENTS IN 1939.—In order to obtain more definite information concerning the possibility of replacing cresylic acid with low concentrations of tar oil, the following sprays were applied on four blocks of apple trees. A dormant spray containing 3 per cent petroleum oil and 2.5 per cent tar oil, three delayed dormant sprays containing 3 per cent petroleum oil with (1) 0.5 per cent cresylic acid; (2) 0.5 per cent tar oil; and (3) 0.66 per cent tar oil. Each block contained the following varieties: 2 Opalescent, 5 Gravenstein, 3 Wealthy and 3 Williams. While all varieties were sprayed for the purpose of studying possible injurious effect, only Opalescent and Gravenstein were kept under observation for aphid control. The dormant spray was applied on March 21 and the delayed dormant sprays on April 4. The composition of the spray mixtures is shown in table 2.

APHID CONTROL.—Counts of all species of live aphids were made on April 24, when the buds were in full pink stage, and of rosy aphids only on June 12. The results presented in table 2 show that the dormant spray produced 100 per cent control of all aphids, on both varieties of trees. Of the delayed dormant sprays, the one containing 0.66 per cent tar oil proved as effective as the spray containing 0.5 per cent cresylic acid, averaging 97.8 per cent control for all species of aphids. It appears from these results that eggs of rosy aphid are somewhat more resistant to delayed dormant sprays than are the eggs of the apple-grain aphid, and green aphid.

INJURY.—Neither bud retardation nor injury of any kind could be noticed on trees which received the dormant spray while slight scorching to tips of well advanced fruit buds appeared in all the delayed dormant blocks within one or two days after spraying. However, at the time when the aphid counts were made this injury was hardly noticeable and it had, apparently, no deleterious effect on fruit bud development and leaf growth. In general, the injury from the 0.66 per cent tar oil was no worse than that usually occurring from the 0.5 per cent cresylic acid.

SUMMARY AND CONCLUSIONS.—Orchard experiments were conducted during 1938 and 1939 on several varieties of apple trees with delayed dormant sprays consisting of 3 per cent petroleum oil combined with various concentrations of tar oil to kill the eggs of aphids and European red mite. These sprays were compared with a dormant spray of 3 per cent petroleum oil and 2.5 per cent tar oil, and with a delayed dormant spray of 3 per cent petroleum oil and 0.5 per cent cresylic acid. The purpose of this investigation was to determine the minimum concentration of tar oil necessary to be added to the petroleum oil in order to obtain about the same control of aphids as with 0.5 per cent cresylic acid, without injury to the buds.

The addition of 0.66 per cent tar oil gave as good control of all species of apple aphids as did the addition of 0.5 per cent cresylic acid with no greater injury to the buds. Eggs of rosy aphids were more resistant to control by delayed dormant sprays than by dormant sprays. Delayed dormant sprays containing 1 per cent or more tar oil retarded the development of fruit buds in general, and severely injured many lateral buds. The addition of tar oil at the delayed dormant stage did not interfere with the efficiency of petroleum oil in control of European red mite. —1-6-40.

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Technique in Control Experiments with Apple Aphids

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In any effort to secure adequate and accurate data, the importance of good technique cannot be overemphasized. Criteria for good biological technique are, first, the technique must be natural; that is, the conditions of the experiment must approximate those of nature; second, it must be simple, not encumbered with unnecessary details which require needless labor. At the present time many excellent techniques are employed in entomological work, but there are relatively few that could not be improved either in naturalness or in simplicity. This statement certainly applies to the technique described in this paper, for the writer is sure that further improvements for it will be found.

Space does not permit a history of the development of the technique now used at the Ohio Agricultural Experiment Station in control experiments with apple aphids. This technique has been developed gradually over a period of about 12 years, during which time the work has frequently dealt with species of aphids on other hosts. The species of apple aphids involved in the present experimental program are the apple-grain aphid, *Rhopalosiphum prunifoliae* (Fitch); the rosy apple aphid, *Anuraphis roseus* Baker; and the apple aphid, *Aphis pomi* DeGeer. All three species are common in Ohio, and the last two are frequently serious pests.

TECHNIQUE IN OVICIDAL TESTS.—Since the eggs of apple aphids are found exposed on branches and twigs during the entire dormant period, it is logical that their destruction should be attempted at that time. Several sprays have accomplished this successfully and have inspired the compounding of many new formulas that require testing. The research technique developed at the Ohio Station is as follows. Any time from January to mid-March, twigs infested with aphis eggs are cut and brought to the laboratory where they are kept outdoors under natural conditions. In experimental setups the eggs of *Aphis pomi* are kept separate but no attempt is made to separate those of the other two species because they hatch at approximately the same rate under the different spray treatments used. Also, the

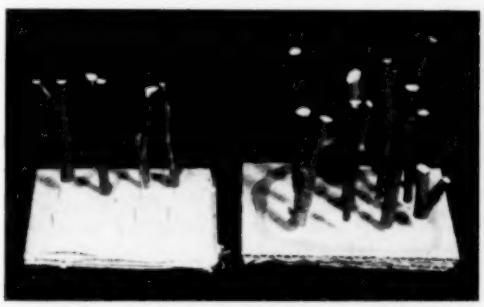

FIG. 1.—Sections of apple twigs, infested with aphid eggs, that have been prepared for spraying. Note tanglefoot band on filled card.

lack of distinct morphological characters makes their separation practically impossible. However, the relative ratio of the two species is usually determined later on the trees or on check lots by counts of the hatched stem mothers.

Shortly before the eggs are counted, the infested twigs are cut in lengths of from 2 to 3 inches. These are kept outdoors in screen baskets. At the time of counting, such a basket of twigs is placed outside a window, through which a few twigs at a time may be brought inside. Usually no more than can be handled in 5 minutes are taken. The normal appearing eggs on each twig are then counted under the binocular microscope, after which the wood, if carrying more than four eggs, is impaled on a pin set upright through a corrugated cardboard base made of two 4-inch squares

pinned together for extra rigidity. The number of twigs for each base will vary according to the abundance of eggs. Lengths of wood with fewer than four eggs are discarded. Frequently nine pinned twigs will carry enough eggs for one replicate, for which 75 to 100 eggs are considered adequate. At times, however, 15 to 20 pins will be needed. As each base or card is filled with infested twigs it is at

FIG. 2.—Young stem-mother aphids trapped in tanglefoot band. ×4.

once set outdoors or taken to a cold insectary. Four replicates are used for each spray treatment. The treatments are applied with a hand or small electric sprayer. Each treatment is put on during the period that similar sprays are being used in the orchard.

As soon as the cardboard bases have dried after the spraying, a thin line of tanglefoot is placed around the margins and the cards are returned to the cold insectary. Here they must be protected from dust by a muslin or cheesecloth cover. When the eggs hatch the young stem mothers soon wander off the twigs and become stuck in the tanglefoot band. In this position they are easily counted under the binocular microscope. The rate and time of hatching are determined by daily counts on one or more check lots. When such counts indicate that hatching is complete, one count for every replicate completes the experiment.

In following the foregoing laboratory procedure, the main point is to keep the eggs indoors for the shortest time possible. All who have done either biological or control work with aphid eggs agree on this point.

Data secured by this procedure are uniform and agree closely with field results. Examples showing the type of data are shown in table 1. It may be added also that the same technique works well with eggs of the European red mite and the apple leaf roller.

In testing ovicidal treatments in the field, the conventional spray procedure is followed except that single tree plots, replicated from six to nine times, are used. The various sprays are applied, each in its appropriate season, but no immediate attempt is made to obtain records. These are made from 4 to 8 weeks later by checking the rate and degree of infestation on a given number of terminals per tree. This method has proved to be both accurate and labor saving.

TESTING MATERIALS AGAINST ACTIVE APHIDS.—Whereas the testing of ovicidal materials concerned the eggs of all three species common to apple, the technique developed for use with living forms has been applied against the apple aphid only. The rosy aphid, because of curled foliage, and the apple-grain aphid, because of early migration, are not suitable for this type of work. Much laboratory work with *A. pomi* has been done by using either infested terminals set in small water containers or single leaves and terminal tips on stretched cheesecloth under large petri plates. This technique is frequently referred to as the embroidery ring-petri plate method. It was developed by Dr. H. F. Dietz and his associates at the Ohio

Table 1.—Ovicidal tests: Percentage of eggs hatching—1939.

MATERIAL NO.	REPLICATE NO. A	B	C	D	MEAN
1	0	0	0	1	0.3
2	24	34	29	24	24.0
3	11	10	9	10	10.0
Check	66	71	52	95	72.0

Station between 1930 and 1935 and is widely used with many aphid species. It has been used with *A. pomi* but owing to the stem feeding habit of this species the method does not work as well with it as for leaf-feeding forms.

At the present time the technique in use at the Ohio Station with *A. pomi* may be called a field-laboratory method. This dual procedure for each material under investigation requires four or more one-tree plots, each of which is a replicate for a combined field-laboratory and field

test. In both tests, a standard power sprayer equipped with spray gun is used for applying the spray materials.

For the field-laboratory test, several terminals are cut from each tree before it is sprayed and these are placed in vials containing water. Each twig is slowly revolved, at a distance of about 5 feet from the spray gun, and sprayed. This plan ensures thorough coverage and does not mechanically disturb the aphid colony. After the spraying, the twigs are tagged, and placed in racks, in the outdoor insectary. Frequently, paper collars are placed around the twigs so that falling aphids will not be lost. Counts of the living and dead aphids on the twig-complement from each tree are made at the end of 24- and 48-hour periods. The combined records of the aphids on all twigs from a given tree constitute a single replicate.

Table 2.—Field-laboratory and field tests with *Aphis pomi*—1938.

Test No.	Laboratory-Field Test		Field Test	
	No. Aphids	Per Cent Dead	No. Aphids	Per Cent Dead
31	1768	98	1387	83
32	1531	100	1739	99
33	881	99	2392	88
34	1590	100	1819	99

After the cut terminals have been sprayed, the entire tree is thoroughly sprayed according to the best orchard practice. This is the field test. Before spraying, however, infested terminals scattered over the tree are selected and tagged. Each tag is marked with the estimated aphid population. This record is made to check against the possible loss of aphids by dropping after the spraying has been done.

Twenty-four or 48 hours after spraying, the trees are visited and several of the tagged terminals are cut off, placed in individual paper bags, and carried to the laboratory for examination and counts. Combining the data from the laboratory and the field procedure gives an adequate picture of the performance of the material. Table 2 gives an example of the type of data that may be expected from this technique.

As indicated by table 2, the field-laboratory test gives the spray material every chance to prove its effectiveness, whereas the field test is much more severe. When the two tests are conducted simultaneously, a double check is obtained on any material under investigation.

The technique which has been described permits a considerable increase in the number of tests possible, and the collection of data of greater quantity and better quality from each.—1-6-40.

Comstock's Mealybug on Apple and Catalpa

JAMES A. COX, *Virginia Agricultural Experiment Station, Blacksburg*

Comstock's mealybug, *Pseudococcus comstocki* Kuwana, attacks a wide range of host plants but in Virginia is considered to be a pest on catalpa and apple only. Hough (1925) reported the insect as a serious pest of umbrella catalpa. He also stated that the mealybug was common on apples and that frequently adult females were found ovipositing in the stem end of York Imperial apples but did not damage the fruit in any way. In 1934 Woodside (1936) found Comstock's mealybug to be a serious pest of apples in Albemarle County, Virginia, and reported that as much as 50 per cent of the fruit was damaged in heavily infested areas. Since the mealybug has been present on apple for a number of years but did not cause any appreciable damage until 1934, it appears that in recent years conditions have become favorable for its development on this host. Mealybugs collected from catalpa and apple have recently been determined as the same species, *P. comstocki*, by Harold Morrison of the Bureau of Entomology and Plant Quarantine.

DISTRIBUTION.—While scouting to determine the exact limits of the area infested by the mealybug has not been done, information accumulated during the last years shows that the insect is now present in many of the apple-growing regions of the State. It was found in 1936 near Roanoke and Winchester where it caused serious damage to the fruit in a few apple orchards. In 1937 the mealybug caused

little injury to apples at Crozet and Roanoke but at Winchester the injury was severe in a few orchards. During 1938 it was present in several orchards at Crozet, Roanoke, and Winchester but caused very little injury to the fruit. In 1939 it severely injured the apples in several orchards at Crozet, Roanoke, and Winchester; in the heavily infested areas as much as 50 per cent of the apple crop was damaged by the insect.

NATURAL ENEMIES.—During 1939 the following species of hymenopterous parasites were reared from Comstock's mealybug: *Clausenia purpurea* Ishii,* *Thysanus nigra* Ashm.,* *Thysanus elongatus* Gir.,* *Pachyneuron altiscuta* How.,* and *Lygocerus* sp.† Of these *C. purpurea* was the most important. This species was described in 1923 by Ishii from material reared from *Pseudococcus* sp. on citrus. It had not been recorded from the United States but had apparently accompanied its host when the latter became established in this country.

In a study of the biology of *Clausenia purpurea*, an attempt was made to determine the percentage of mealybugs parasitized by it. Mealybugs collected from apple and catalpa were dissected and a record was kept of the number containing parasite larvae. In an orchard in the vicinity of Roanoke where the mealybug had been present for years, the parasitism was as follows: first brood, 4 per cent; second brood, 14 per cent; and third brood, 44 per cent. In another orchard in that locality the parasitism for the third brood was 20 per cent. Near Crozet the parasitism in one collection for the third brood on apple was as follows: Orchard number 1, 70 per cent; orchard number 2, 26 per cent; and orchard number 3, 5 per cent. In Salem the third brood of mealybugs from catalpa was 94 per cent parasitized.

It is unfortunate that more information is not available on the parasitism throughout the season on apple and catalpa; however the data from apple indicate that the parasitism of the first brood is low and that it gradually increases during the development of the second and third broods. The low parasitism of the first two broods may be due to high mortality of the parasites during the winter or to the killing of parasites by the insecticides and fungicides used in apple orchards.

An undetermined fungus destroyed a large number of mealybugs on certain catalpa trees, but very few of the mealybugs on apple have been found attacked by the fungus. The small number of mealybugs infected with the fungus in apple orchards is probably due to the presence of a fungicide on the apple trees, whereas catalpa trees are rarely sprayed with a fungicide.

MEALYBUG INFESTATION AND ORCHARD MANAGEMENT.—In regard to orchard management, the apple orchards in Virginia may be divided into three classes: Those that receive both the standard spray treatment and annual applications of nitrogenous fertilizers; those that receive one or two arsenical sprays and no fertilizers; and those that are neither sprayed nor fertilized.

There are several questions concerning the mealybug infestation in relation to orchard management that can be answered only after more study. Observations during 1939, however, indicate that the orchards of the first class were more heavily infested with mealybugs than orchards of the other classes. In several instances commercial orchards which had received the recommended applications of fertilizer and had been sprayed according to the spray schedule were heavily infested, whereas in adjoining orchards which had received only one or two sprays and no fertilizer, the mealybugs, though present, caused no damage to the fruit. To what extent the annual application of fertilizers affects the infestation of mealybugs cannot be definitely stated. However, from the information we have, it appears that nitrogenous fertilizers produce a condition which is favorable for the development of the mealybug.

SUMMARY. — Comstock's mealybug, *Pseudococcus comstocki* Kuwana, attacks a wide range of host plants but in Virginia is a pest of apple and catalpa only. It has been known as a pest of catalpa since 1923 and was first found causing damage to apple in 1934. The insect is now a pest in many orchards in some of the principal apple-growing regions of Virginia.

The heaviest infestations of mealybugs were found in commercial orchards that had been thoroughly sprayed and had re-

* Determined by A. B. Gahan, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

† Determined by C. F. W. Muesebeck, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

ceived annual applications of fertilizer. In adjoining orchards that were not fertilized and had received only one or two arsenical sprays, a few mealybugs were present but they did not cause any injury to the fruit.

The following species of parasites were reared from Comstock's mealybug: *Clausenia purpurea* Ishii, *Thysanus nigra* Ashm., *T. elongatus* Gir., *Pachyneuron altiscuta* How., and *Lygocerus* sp. *C. purpurea* was the most important parasite reared.—1-6-40.

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Spray Residue and Substitutes for Lead Arsenate in Control of Cherry Fruitflies

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For a number of years commercial control of the cherry fruitfly—(*Rhagoletis cingulata* (Loew)) and the black cherry fruitfly (*R. fausta* (O.S.)) has been maintained in the Hudson River Valley by the method reported by Glasgow and Gambrell (1926). This method consists of two spray applications of lead arsenate ($2\frac{1}{2}$ pounds per 100 gallons) during the time adult fruitflies are emerging. Control is accomplished by poisoning the flies during their preoviposition period, that is, within 10 to 12 days after they emerge from the soil. While this program has resulted in adequate control of both species of fruitflies, considerable difficulty with excessive residues of lead and arsenic has been encountered in recent years by growers using this schedule, especially in the case of cherries to be marketed as fresh fruit. The results of preliminary studies of spray residues resulting from various programs have already been reported (Hamilton & Pearce 1938). These workers concluded that when $2\frac{1}{2}$ pounds of lead arsenate per 100 gallons is used in the true shuck-fall spray the use of any arsenical in sprays thereafter is likely to cause excessive residue loads at harvest. It was also noted that when only 1 pound of lead arsenate per 100 gallons is used in the true shuck-fall application additional light dosages of arsenicals can still be applied early in June. Glasgow (1935) recognized the difficulties encountered with lead arsenate and tested possible substitutes. These tests indicated that derris containing 4 per cent of rotenone could be used satisfactorily in place of lead arsenate. Studies to determine the kind, date of application, and quantity of arsenical that can be safely applied to cherries without causing residues above the tolerances at harvest were conducted by the writer in Columbia County, New York, from 1937 through 1939. Field tests of materials that might possibly be used as lead arsenate substitutes to control cherry fruitflies were also made during this period.

SPRAY-RESIDUE STUDIES.—Data from certain representative plots included in the spray-residue studies are presented in table 1.

Lead residues ranged from 0.007 to 0.024 grain per pound of fruit in plots receiving $2\frac{1}{2}$ pounds of lead arsenate per 100 gallons of spray at shuck fall only. This variation was influenced by the variety and the rainfall, and indirectly by the growth of the fruit. In no instance did the residue exceed the tolerance of 0.025 grain per pound of fruit. Where only 1 pound of lead arsenate was used per 100 gallons of spray at shuck fall, at least one spray containing 1 pound of basic zinc arsenate per 100 gallons could be safely applied during June.

Calcium arsenate was also used in cer-

* These studies were conducted in cooperation with the New York State Agricultural Experiment Station, Geneva. The writer is particularly indebted to P. J. Chapman and Hugh Glasgow of the State experiment station for suggestions and advice as the work progressed.

Table 1.—Spray residues on cherries at harvest,* Hudson River Valley, N. Y., 1937-39.

Plot	Year	Variety	Arsenical in Spray	Pounds per 100 Gallons			Residue, Grains per Pound		Rainfall (Inches)	
				Shuck-fall Spray	First Maggot Spray	Second Maggot Spray	Arsenic (As_2O_3)	Lead (Pb)	Shuck-fall to First Maggot Spray	First Maggot Spray to Harvest
1	1937	Windsor	Lead arsenate	2½	2½	2½	0.047	0.105	2.60	6.44
	1937	Montmorency					.085	.146	2.51	6.44
	1937	E. Morello					.024	.052	2.51	8.17
2	1939	Windsor	Lead arsenate	2½	1	—	.015	.037	2.65	1.61
3	1939	Windsor	Lead arsenate	2½	—	—	.006	.010	4.65	4.77
	1939	Windsor	Basic zinc arsenate	—	1	—	.014	.018	2.65	1.61
4	1939	E. Morello	Lead arsenate	1	—	—	.017	.009	2.33	1.96
			Basic zinc arsenate	—	1	1				
5	1939	E. Morello	Lead arsenate	1	—	—	.004	.006	2.33	1.96
			Basic zinc arsenate	—	1	—				
6	1937	Windsor	Lead arsenate	2½	—	—	.003	.011	2.60	6.44
	1938	Windsor					.005	.010	4.65	4.77
	1939	Windsor					.008	.024	2.65	1.61
	1937	Montmorency					.003	.007	2.51	6.44
	1937	E. Morello					.002	.007	2.51	8.17

* Analyses made by G. W. Pearce and A. W. Avens, New York State Agricultural Experiment Station, Geneva.

tain of the residue experiment plots. This material caused so much foliage and "dry stem" injury that the advisability of its use for cherry fruitfly control is questionable.

MATERIALS TESTED FOR CONTROL OF FLIES.—During each of the three years experiments were conducted with cubé

FIG. 1.—Emergence cage placed under a Montmorency cherry tree. The cage was 10 by 10 by 3 feet.

root, containing approximately 5 per cent of rotenone, and with phenothiazine. Basic zinc arsenate was used in 1938. The phenothiazine dust was prepared by a commercial micronizing process with walnut-shell flour and sulfur. In most instances soybean flour was used at the rate of ½ pound per 100 gallons as a spreader and sticker and seemed to be satisfactory for this purpose. A commercial spreader which seemed to be composed primarily of oil was used in a few treatments.

In the residue experiments hydrated lime was used with the arsenicals in equal parts. Liquid lime-sulfur (2 gallons per 100) was used as a fungicide in shuck-fall applications. In 1937 and 1938 flotation sulfur paste (6 pounds per 100 gallons) was added to the maggot sprays. Powdered skim milk (one-half pound per 100 gallons) was used as a spreader and sticker. Wettable sulfur (4 pounds per 100 gallons) and soybean flour (one-half pound per 100 gallons) were used in the maggot sprays during 1939.

TYPES OF ORCHARDS USED.—Since the adult flies have a tendency to travel long distances, the selection of isolated plantings, or extremely large blocks of still larger plantings, for each treatment is necessary to prevent adults flying in from untreated plantings and ovipositing before they feed and are killed by the poison present. Although this method does not allow for an untreated check against the treatment used, it has been observed repeatedly that orchards heavily infested with fruitflies continue to remain so until they are thoroughly treated with an effective material. A further check is obtained by covering the soil under one of the trees in each orchard with an aster-cloth emergence cage (Fig. 1) and determining the actual number of flies emerging. This gives some idea of the infestation that would probably develop in the absence of treatment.

FLY EMERGENCE AND TIMING OF SPRAYS.—Since cubé root and phenothiazine are not so stable as lead arsenate, it was especially important to time their ap-

plication in accordance with fruitfly emergence. This was done by the use of the emergence cage already mentioned (Fig. 1). In Columbia County, N. Y., emergence of the black cherry fruitfly begins about May 30, reaches a peak between May 31 and June 5, and ceases about June 14. That of the cherry fruitfly begins about June 4, reaches a peak from June 10 to June 20, and ceases about July 1. The black cherry fruitfly was found in 6 of the 16 orchards in which cages were placed. Not any of the 6 orchards included English Morello cherries. This variety may mature too late in the season to become infested by this species. The cherry fruitfly was found in all the 16 orchards.

If the black cherry fruitfly is present in large enough numbers to be injurious, the first maggot spray should be applied about June 4. When only the cherry fruitfly is present the first spray may be delayed until about June 11 in the locality where this work has been carried on. Since both phenothiazine and cubé root weather rapidly, applications were made 8 to 10 days apart until fly emergence was over. When heavy rains occurred more frequent applications were necessary.

METHOD OF ESTIMATING RESULTS.—It was necessary to develop a method of estimating the infestation that was not too time-consuming. This was done by selecting two trees at random in each orchard and carefully picking all fruit from them prior to the time mature maggots began leaving the cherries. Three 1-pound samples of cherries from each tree were then counted to determine the number of fruits per pound. Then the total crop from each tree was weighed and the number of cherries per tree estimated. The fruit was then placed in rodent-tight trays (Fig. 2), which had bottoms constructed of hardware cloth and were originally designed by the New York State Agricultural Experiment Station for use in apple maggot investigations. The trays were placed over pans of water (Fig. 2), and the larvae emerging from the cherries dropped into the water and drowned. The water from these pans was strained twice weekly, and the maggots were counted. The rate of infestation was then determined as the number of maggots per 100 fruits and the number of maggots per tree. The results would have been more accurate if more trees could have been used for infestation records from each planting, but the number used was limited by the amount of equipment and space available for collecting the emerging maggots.

RESULTS OF TESTS OF SUBSTITUTES.—A summary of the materials used and the results obtained with substitute materials is given in table 2.

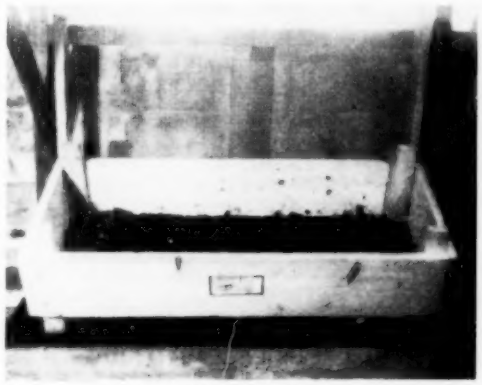

FIG. 2.—Tray used to rear out maggots of cherry fruitflies. The top and bottom are made of 2-mesh galvanized hardware cloth and prevent rodents from feeding on the maggots. Mature maggots drop through the cloth into a pan of water, which is strained to recover them. Each tray held from 10 to 15 pounds of cherries.

In the tests of cubé root the number of maggots per tree ranged from 5 to 90, and the estimated number of maggots per 100 fruits ranged from 0.07 to 1.38. Records from the emergence cages erected in these plots indicated that enough flies were present so that much heavier infestations would have occurred if the control measures had not been effective. On English Morello cherries less injury in the form of "dry stem" occurred where cubé root was used than where even 1 pound of lead arsenate per 100 gallons was used.

The experiments conducted with phenothiazine in 1937 and 1938 indicated that phenothiazine was as effective as cubé root when the same dosages and number of treatments were used. The high infestation in test 4 (318 maggots per tree and 4.56 per 100 fruits) was attributed to the omission of the third maggot spray. In 1939 phenothiazine was compared more directly with cubé root by using the two materials in the same orchard (Tests 10 and 12). In this orchard the phenothiazine plot had 1.24 maggots per 100 fruits as compared with 0.07 maggot per 100

fruits for the cubé root. Perhaps this was because during 1939 the rainfall was less, or it may have been that the initial infestation in the part of the orchard treated with phenothiazine was greater. A 15 per cent phenothiazine dust reduced a previously heavy infestation to 0.90 maggot per 100 fruits, or only 30 maggots per tree. In the dusted orchard less phenothiazine was deposited than in a similar orchard sprayed with 1 pound of phenothiazine per 100 gallons, according to the analyses made by the Division of Insecticide Investigations of the Bureau. However, the control appeared to be greater where the dust was used. The dust was apparently less effective than a spray containing 2 pounds of phenothiazine in 100 gallons. One pound of phenothiazine in 100 gallons of spray did not adequately control the fruitfly (Test 6, Table 2). Consequently the minimum quantity of phenothiazine that can be used effectively appears to be 2 pounds per 100 gallons. Phenothiazine is not so pleasant to use as cubé root because it burns the skin of those working with it.

Basic zinc arsenate applied in 1938 at a strength of 1 pound per 100 gallons in the first maggot spray and one-half pound in the second application appeared to reduce a previously heavy infestation to 3.21 maggots per 100 fruits. Although this cannot be considered satisfactory control, it was evident that the treatment had a certain degree of effectiveness. However, on such varieties as English Morello, where only 1 pound of arsenical per 100 gallons is applied at shuck fall, zinc arsenate could be substituted for cubé root at the rate of 1 pound per 100 gallons in the first maggot spray, thus reducing the number of cubé applications needed and the cost of the program.

Table 2.—Summary of field experiments with insecticides for control of cherry fruitflies Hudson River Valley, N. Y., 1937–39.

Test No.	Year	Materials*		Number of Applications	Average Number of Fruits per Tree	Average Number of Maggots per Tree	Average Number of Maggots per 100 Fruits**
Variety Montmorency							
1	1938	Cubé root (4.4% rotenone)†	2 lbs.	3	2,556	37	1.38
2	1939	Cubé root (4.4% rotenone)†	2 lbs.	3	3,928	16	0.37
3	1937	Phenothiazine	2½ lbs.	3	3,106	3	0.10
4	1938	Phenothiazine	2 lbs.	2	4,617	318	4.56
5	1939	Phenothiazine	2 lbs.	3	4,109	16	0.40
6	1939	Phenothiazine	1 lb.	3	6,614	188	2.68
7	1939	Phenothiazine dust	15 per cent‡	3	3,681	30	0.90
Variety English Morello							
8	1937	Cubé root (5.3% rotenone)†	2½ lbs.	3	5,197	25	0.35
9	1938	Cubé root (4.4% rotenone)†	2 lbs.	4	7,573	90	1.13
10	1939	Cubé root (4.7% rotenone)†	2 lbs.	3	8,131	5	0.07
11	1938	Phenothiazine	2 lbs.	4	5,898	18	0.31
12	1939	Phenothiazine	2 lbs.	3	10,233	125	1.24
13	1938	Basic zinc arsenate	1 lb. and ½ lb.	2	3,900	122	3.21

* Quantities are for 100 gallons of spray mixture. In most instances soybean flour (½ lb.) and flotation-sulfur paste (6 lbs.) were used as sticker and fungicide during 1937 and 1938. During 1939 soybean flour (½ lb.) was used as a sticker except in tests 2, 5, and 7. A commercial spreader (1 pint) was used in tests 2 and 5.

** Unweighted average.

† Determinations of rotenone content made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

‡ Dust consisted of 15 per cent phenothiazine, 25 per cent walnut-shell flour, and 60 per cent sulfur, all processed by micronizing.

The insecticides seemed to stick better with flotation sulfur paste as the fungicide than with wettable sulfur. Flotation sulfur paste left a heavy visible residue when used just before harvest.

SUMMARY.—Lead arsenate has been used effectively to control cherry fruitflies, but residues have been above the tolerances at harvest. Analyses of cherries show that when lead arsenate is used at the rate of 2½ pounds per 100 gallons of spray at shuck fall, the use of arsenicals in the maggot sprays will create excessive residues. Where danger of arsenical injury prevents the use of more than 1 pound of lead arsenate per 100 gallons at shuck fall, a pound of basic zinc arsenate may be applied in the first maggot spray.

Field experiments were carried on with cubé root and phenothiazine as possible substitutes for arsenicals for the control of cherry fruitflies. Because of the habits of the flies it was necessary to spray large blocks of big plantings or use isolated plantings for tests of spray treatments. Since cubé root and phenothiazine weather rapidly, their application was closely timed according to the species of fruitflies present and the time of their emergence. A satisfactory method for making infestation records, which consisted of rearing out all maggots from certain trees, was developed.

Both cubé root and phenothiazine reduced heavy populations of fruitflies satisfactorily when at least three applications were made at the rate of 2 pounds per 100 gallons of spray. In one test a 15 per cent phenothiazine dust appeared to be nearly as effective as these sprays. Basic zinc arsenate only partially controlled cherry fruitflies when two light applications were made.—1-6-40.

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Control of Plum Curculio on Peach in Illinois

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Peach growers in Illinois and surrounding states depend almost entirely upon spraying and dusting to control the plum curculio, *Conotrachelus nenuphar* (Hbst.). Commercial jarring and removal of wormy drop peaches, commonly practiced in the southeast, are not considered by them to be practical in Illinois. For this reason we have made a study over a period of years to find the most efficient and the safest poison to use, and the best, times and places to use it.

FOLIAGE INJURY STUDIES.—This year, as well as in the past, arsenical sprays produced more injury than arsenical oil dusts where the same number of each was applied. The sprays were used at the rate of 3 pounds of lead arsenate in 100 gallons with zinc sulfate lime as a buffer, about 3 gallons applied to each mature tree, and the oil dusts at the rate of three-quarters ounce per tree, the dust containing 10 per cent lead arsenate. Synthetic cryolite used at 4 pounds in 100 gallons in our tests, and by growers, has never produced foliage injury but has injured the fruit. The average number of drop leaves per tree in our plots in 1939 was as follows:

Checks, no treatment	815 leaves
Cryolite	772 leaves
Lead arsenate oil dust	1109 leaves
Lead arsenate spray	3144 leaves

This shows that about three times as many leaves dropped from trees sprayed with lead arsenate as from those dusted, and four times as many as from untreated trees. Very similar counts were secured in 1938.

This year, to combat a threatened increase in curculios, several growers used excessive and unwarranted numbers of oil dust applications; five to ten. The result was considerable arsenical injury as was to be expected.

CRYOLITE, CONTROL AND INJURY TESTS.—Because of lack of injury to foliage and the general interest by peach growers in the use of synthetic cryolite, we conducted studies on control and possible fruit injury. Very unfavorable results with synthetic cryolite had been reported to us by Oliver I Snapp, in Georgia, and our own earlier tests with the natural material were not promising. No noticeable injury was observed until the season of 1939 when injury was found quite generally in the few orchards in which cryolite was tried. As many of these as possible were examined at harvest and counts made of wormy and injured fruit. Four orchards were found in which there

were comparable blocks, which had received the same number of sprays or dusts of each material, which had been apparently subjected to equal attack by the plum curculio. The results of these examinations at harvest are given in table 1. Our own tests with synthetic cryolite began in 1938 and final counts are also included in this table and listed as Orchard No. 5. These are averages for 1938 and 1939, whereas Orchards 1 to 4, growers tests, are for this season only.

Table 1.—Tests with synthetic cryolite on peaches.

Orchard Number	Per Cent Peaches Wormy			Per Cent Fruit Injured by Cryolite
	Lead arsenate	Cryolite	Checks	
1	1.7	1.7	—	10.0
2	1.7	7.0	—	1.0
3	.6	30.2	—	31.2
4	.6	.2	17.2	14.6
5	2.8	4.9	11.8	1.4
Average	1.5	8.8	14.5	11.6

This table shows quite variable results both as regards control and injury, but averages show cryolite in a very unfavorable light as compared with lead arsenate. We conclude from these tests and from the similar experiments by Mr. Snapp that cryolite is a risky and unreliable substitute for lead arsenate for curculio control on peaches.

Control Tests with Oil Dust.—Eliminating cryolite we return to the safer of the two methods of applying lead arsenate, the use of oil dust. Oil dust has been used on peaches in Illinois since 1929. For 8 years we have had tests comparing liquid and oil dust using the former at 3 pounds to 100 gallons, 3 to 4 gallons per tree, and the oil dust at a 10 per cent strength of the poison in a dust containing 5 per cent oil with sulfur talc and lime using about three-fourths pound dust per tree. From 2 to 4 applications of each material were given, depending upon infestation. The results of these tests are summarized in table 2.

This shows less than $\frac{1}{2}$ per cent difference in wormy fruit over a period of eight seasons.

Concentration of Poison in Infested Areas.—Since some foliage injury may occur even with oil dust where excessive numbers of applications are given, and since some growers are equipped only for spraying, it is important to apply poisons only where curculios are present in sufficient numbers. For this reason we have continued our studies with jarring to determine the occurrence of plum curculio in peach orchards. For several years jarring during the first part of the season has shown considerably more curculios in the outer rows of the orchard than farther in. On the strength of such data two growers were induced in 1938 to agree to jar for curculio and to poison according to their findings. The first grower, finding most of his curculios in the first four rows, dusted a forty-acre orchard only once, over the entire area, and three times in the outer four rows with the result that his infestation at harvest, according to my counts was 0.2 per cent in the center of the orchard where only one dusting had been applied and 0.6 per cent in the four outside rows which had received three. A ton of oil dust was saved and possibly some arsenical injury was avoided. The other grower left 20 rows in the center with absolutely no poison and at harvest there was again found even fewer wormy peaches 0.5 per cent in the center, compared with 3 per cent in the outer rows

Table 2.—Plum curculio control, 8-year average.

Material Used	Per Cent Wormy Fruit
Lead arsenate spray, 3 pounds to 100 gallons	2.2
Oil dust with 10% lead arsenate, 5% oil	2.6
Check plots, no treatment	15.1

which had been dusted twice. A considerable saving of materials again was effected. In 1939 trees were jarred at weekly intervals, from petal fall to harvest, in the outside row next to a woods and in the fifth row back from the edge. Ten trees were jarred each time and the beetles counted and released. The entire orchard received three sprays. The data are shown in figure 1. For the entire season, three times as many curculios were jarred from the first row as from the fifth. It will be seen that there never was

a time throughout the season when the fifth row showed as many curculios as the outer row. Following the first big drop in numbers of curculios, which is normal to both sprayed and unsprayed orchards, there is a rise in numbers coming about a month before harvest. This is shown in the graph and represents the new brood of beetles. In Illinois there is usually little or no second brood produced by these beetles but they do feed and in occasional years it has seemed advisable to poison for them. The jarring records shown in the graph indicate that even as late in the season as this, curculios have not migrated in any large numbers beyond the outer rows, and poisoning to be done at this time could be confined quite largely to these areas. Jarring in many other orchards shows that old apple orchards or ravines through the peach orchard, or neglected fence rows may be the source of the incoming curculios, and growers should jar to determine the points of greatest abundance.

CONCLUSIONS.—Lead arsenate applied to peach in the form of oil dust usually produces much less injury than when applied as a liquid spray, but excessive numbers of dust applications, five or more, may cause serious injury. Eight seasons' tests with oil dust containing 10 per cent lead arsenate and 5 per cent oil show practically no difference in control of plum curculio from lead arsenate sprays used at 3 pounds to 100 gallons. Cryolite is an unreliable and sometimes dangerous substitute for lead arsenate for control of plum curculio on peach. Jarring shows considerably more curculios at the edge of a peach orchard than are present even

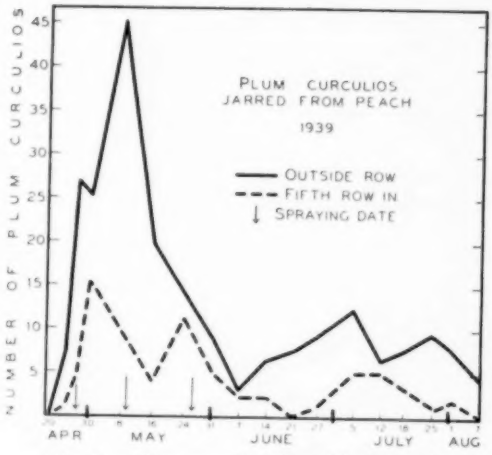

FIG. 1.—Plum curculios jarred from peach trees, 1939.

a few rows in from the edge. The best procedure from the standpoint of economy, efficiency and safety to fruit and foliage, is to use a minimum number of oil dust applications over the entire orchard with others at the edges or where jarring indicates abundance, and orchard tests show this procedure to be practical. —1-6-40.

Further Studies of the Plum Curculio in the Georgia Peach Belt

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Although a comprehensive study of the life history and habits of the plum curculio in the Georgia peach belt was made by the writer during the years 1921–24 (Snapp 1930), a need for additional information on certain phases of the biology of this insect has developed since this report was published. As there is usually a large second generation of the plum curculio in central Georgia, studies were conducted during the period from 1936 to 1939 to determine the percentage of first-brood females depositing eggs during the year of their emergence and to obtain other data on the life history and habits of this insect.

PERCENTAGE OF FIRST-BROOD FEMALES DEPOSITING EGGS.—Studies were conducted during four seasons to determine the percentage of first-brood females that deposited eggs. In 1937 and 1939 the individual pairs used for this work were selected at intervals throughout the first-brood emergence period, the numbers being as far as possible in proportion to the numbers emerging. In 1936 and 1938 most pairs were from the earliest maturing portion of the brood. All females

Table 1.—Egg deposition by first-generation plum curculios during year of emergence at Fort Valley, Ga.

Year	Number of Pairs	Date of First Oviposition	Females Ovipositing	Females Not Ovipositing— With Eggs Formed	Females Not Ovipositing— With No Eggs
1936	302	June 17	48.7%	0.7%	50.6%
1937	101	July 6	70.0	0	30.0
1938	100	June 15	71.0	3.0	26.0
1939	44	June 28	52.3	0	47.7

that had not oviposited were dissected at the end of the season to determine whether or not they contained eggs. The results of these studies, which are presented in table 1, show that one-half to three-fourths of the females deposited eggs. These findings substantiate observations in the field, where a second brood of plum curculio larvae damaged peaches of the late varieties each of these years. In 2 of the 4 years females not ovipositing were found to contain no mature or immature eggs and in the other 2 years only 0.7 and 3.0 per cent of them contained eggs. Many of the first-brood females that oviposit during the year of emergence enter hibernation at the end of the season.

TIME REQUIRED FOR EGGS TO DEVELOP IN THE FEMALE.—As observations had indicated that plum curculio females do not begin to oviposit immediately after emerging from the soil or coming out of hibernation, a study was undertaken to determine the period required for eggs to form and mature in the bodies of these insects. During the period 1936–39 successive daily dissections of curculios were made after their appearance from hibernation and emergence from the soil.

With over-wintered females eggs usually began to develop within a week after emergence from hibernation but did not become mature and ready for deposition until about 1 month after emergence. Females taken from hibernation during the winter and early spring showed no egg formation. It had been previously observed that plum curculios do not begin to deposit eggs in peaches for a period of a month after they appear from hibernation. Therefore, peach growers have an opportunity to apply a spray for the control of this insect before the eggs mature.

With first-brood females a period of about 1 month after emergence from the soil was usually required for eggs to mature. In 1937 one individual began to oviposit on the twenty-third day following emergence, and in 1938 two individuals began to deposit eggs on the fifteenth day following emergence. These records, however, were unusual, and these three individuals may have remained in the soil as adults, following transformation from the pupae, for a longer period than usual, in which case egg development probably began before emergence.

DISPERSAL OF CURCULIOS IN PEACH ORCHARDS.—A study was made during 1939 to determine the distance newly emerged plum curculios move before they begin oviposition. Six hundred and forty-nine curculios of the first generation which had not begun to deposit eggs were used for this work. Each beetle was marked and released on the same peach tree in a commercial orchard bounded on three sides by woods. A large number of peach trees located in all directions from the release tree were jarred at frequent intervals for recovery of marked beetles. Most of these curculios remained on the release tree. A few were recovered on the first and second trees from the release tree. Five were recovered three trees away, six were recovered four trees away, and two were recovered six trees away. These results indicate that, following emergence from the soil, the movement of first-brood adults is confined mostly to the tree on which they are released or trees nearby. An occasional individual may move as far as six trees, or 100 feet.

From the study of a large number of marked plum curculios in 1936 it was determined that overwintered adults will travel from tree to tree even if there is fruit for food and oviposition, but that their travel is confined to but a few adjacent trees after they have dispersed through the orchard following appearance from hibernation. These adults spend some of the time on the ground during the growing period of the fruit.

A study of 1,500 marked plum curculios in 1936 showed that adults of the first generation do not travel from one orchard after the peaches are harvested to another where there are peaches. Adults of the second generation do not appear to migrate from the orchard in which they are reared to other orchards before they enter hibernation.

HIBERNATION STUDIES.—Although it has been generally accepted that the adults hibernate in wooded areas and other cover adjoining and near peach orchards, very few individuals have actually been found in hibernation; this has led to some speculation as to just where the insect spends the winter. During the winter of 1937–38 large quantities of debris (leaves, woods mold, sticks, pine cones, etc.) collected from the edges of woods bordering peach orchards were examined for hibernating curculios. The material was placed in a thin layer on a piece of sheet tin which had turned-up edges and was mounted on drain tiles. When a slow fire was burning under this apparatus, the beetles in the debris would crawl out as the material warmed up and could be easily captured. Many plum curculio adults were recovered from hibernating material by this method, and it was definitely determined that the insect does hibernate in debris along the edges of woods bordering and near peach orchards.

In some years very few first-generation adults are found on peach trees shortly after peach harvest. On August 4, 1938, a number of adults were recovered from debris collected along a railroad right-of-way adjoining a peach orchard, an indication that in central Georgia plum curculio adults begin to enter hibernation in midsummer, within a month after peach harvest.

APPEARANCE OF CURCULIOS IN THE SPRING.—Chandler (1938) states that at Carbondale, Illinois, 12 years of jarring records showed very few curculios in the orchard before the "shuck-off" stage. The shuck-off stage occurs 10 days or more after petal-fall. That condition seems to exist in peach orchards in many northern sections of the country but in the South the beetles usually begin to appear from hibernation when peach trees bloom and are disseminated throughout the orchards by the time of, or before, petal-fall. Table 2 shows the degree to which the appearance of these insects in the spring coincides with the blossoming of the first-blooming varieties of peach.

In 5 of the last 7 years plum curculios began to appear on peach trees before full bloom and in 6 of these years they were disseminated throughout the orchards by the time three-fourths of the petals had fallen. Although the beetles began to appear from hibernation before petal-fall in 1936, they did not become disseminated throughout the orchards that year until after shuck-off. It is during the period between petal-fall and shuck-off that the adults feed on the calices, petals, and leaves; and when they appear from hibernation by petal-fall, an application of lead arsenate at that time poisons many before they are ready to begin oviposition and before the peach is exposed. Only in 1936 would the petal-fall application of spray not have been advisable.

Table 2.—Date of appearance of the plum curculio from hibernation at Fort Valley, Ga., with reference to the blossoming period of the first-blooming varieties of peach trees.

YEAR	APPEARANCE OF CURCULIOS		FULL BLOOM	PETAL-FALL (¾ DOWN)	SHUCK-OFF STAGE
	First Curculios	Throughout Orchards			
1933	March 23	March 28	March 25	April 5	April 15
1934	March 21	March 28	March 29	April 9	April 20
1935	March 12	March 22	March 17	March 25	April 8
1936	March 16	April 10	March 10	March 19	March 31
1937	February 8	March 31	March 7	March 31	April 14
1938	March 4	March 15	February 28	March 15	March 23
1939	March 6	March 16	March 12	March 18	March 28

SUMMARY.—Further studies on the life history and habits of the plum curculio in the Georgia peach belt were conducted at Fort Valley during the period from 1936 to 1939. It was found that approximately one-half to three-fourths of the females of the first generation deposited eggs during the year of emergence. Dissections at the end of each season showed practically no egg development in females that had not oviposited. Following emergence from the soil, and appearance from hibernation, about one month was required for eggs to mature.

The movement of first-brood adults following their emergence from the soil was confined mostly to the tree from which they came and to trees nearby. Overwintered adults were found to travel from tree to tree even if there was fruit for food and oviposition, but after they became disseminated throughout the orchard their travel appeared to be confined to but a few adjacent trees. These adults did not seem to travel from an orchard, after the peaches were harvested, to other orchards, before entering hibernation.

The plum curculio was found to enter hibernation in midsummer within a month after peach harvest and to hibernate in debris along the edges of woods bordering and near peach orchards. In 5 of the last 7 years this insect appeared on peach trees before full bloom and in 6 of these years they were disseminated throughout the orchards by the time three-fourths of the petals had fallen.—1-6-40.

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Certain Host Plants of the Cotton Flea Hopper*

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In Texas the preferred host plants of the cotton flea hopper, *Psallus seriatus* Reut., from early spring until frost are certain members of the family *Euphorbiaceae* included in the genus *Croton*. These are known locally as sageweed, goatweed, and doveweed. Reinhard (1926) reported that "in cases of severe infestation, 20 to 30 nymphs, may be found on a single croton head." The present writer has often taken over 1,000 adult flea hoppers per 100 sweeps in croton using a net 16 inches in diameter. Reinhard (1928) showed *Croton capitatus* Michx. to be the most important overwintering host plant in central Texas, over 21,000 flea hopper nymphs emerging in the spring of 1927 from 100 plants placed in a hibernation cage the preceding fall. Evidently those factors which determine the abundance of croton thus indirectly influence the abundance of the cotton flea hopper.

The principal factor influencing the abundance of croton is agriculture. This is evident particularly in the sandy upland soils of the oak-hickory region of Texas in the vicinity of College Station. Here *Croton capitatus* Michx., the most common species, suddenly appears in nearly pure stand in freshly disturbed soil. It varies widely in abundance in accordance with land utilization. During the past six years records have been made of these variations in abundance in the above vicinity.

STUDIES OF CROTON.—In the fall of 1934 and winter of 1935 fifty-two fields were selected for study. Care was taken that a wide variation in abundance of corton was included in these fields. They differed in character from fields which had lain fallow during the past crop-growing season with great numbers of croton plants present to freshly cleared woodland fields with no croton present. In each of these fields, one or more areas, each 100 feet long by 3 feet wide, were selected. Starting with 1934, records have been made in the fall of each year in these areas of the number of croton plants present, their average height, and the land utilization during the past crop-growing season.

It was found that most of the areas selected could be grouped in one of seven classes as follows: grassland, terraces, fallow one year, fallow two years, pasture, corn, and cotton.

By grassland is meant fields which have not been grazed and never have been in cultivation or which have been out of cultivation long enough for grass to become dominant. In the fields included in these studies grasses belonging to the genus *Aristida* were dominant. Such fields have very little croton present

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and show little variation in numbers of croton plants per acre from year to year. The average number of croton plants per acre in undisturbed grassland for the six years was 111. The average yearly variation was from 70 to 145 crotons per acre.

Croton capitatus springs up abundantly in freshly disturbed soil. It appears in dense stands along freshly dug ditches and on the tops of new terraces. In 1934 a count made in a field with a heavy growth of grass gave 145 crotons per acre. These plants averaged four inches in height and had only 1 or 2 seed capsules per plant. In the early spring of 1935 this field was terraced and a count made the following fall along these terraces showed 20,200 crotons per acre. These plants averaged 18 inches in height and had approximately 20 seed capsules per plant. The average number of plants per acre, along terraces, for the two years when records were taken was 9,500.

Fields which have lain fallow for a year show a very high croton population. These fields have been cultivated the preceding year and have the soil in excellent condition for the propagation of croton. One field of this kind in 1938 had 175,400 plants per acre. The average number of crotons per acre for the six year period was 16,100. Crotons in these fields were also taller and more branched than in any other type of field.

Fields which have been fallow for two years usually have a greater number of species of annuals present. Because of this competition and because the soil is much harder in such fields there is less croton present. For the six years the average in fields fallow two years was 3,600.

Under the term "pastures" is included fields in which grass is dominant and which were grazed the previous season. There has been a wide variation in the number of croton plants in these pastures from year to year. In 1934, for example, there were 1,400 croton plants per acre and in 1938 the number recorded was 48,300 per acre. The average for the six years 1934–39 was 17,000 plants per acre.

While croton increases greatly in freshly broken fields it disappeares rapidly under constant cultivation. A comparison of the numbers of crotons in the fall in cottonfields and cornfields illustrates this point.

In the region where these data have been collected cotton is frequently cultivated until the third week in August. Nearly all weeds are either killed by this cultivation or, in carefully cared-for fields, are chopped out. On the other hand corn is rarely cultivated after the first week in June. These cornfields will not be disturbed the rest of the summer. As croton will continue to come up all summer and as late as October such cornfields offer good conditions for a large croton population to develop.

Counts of croton have been made in 39 cottonfields. The average for the six years of 1,700 crotons per acre. In over half of the fields no croton was present. In 47 cornfields in which fall counts have been made the average number per acre for the period is 7,000.

In table 1, are shown the characteristic variations in croton populations per acre following several agricultural practices. The effect of these practices on the average height of the plants is included.

Table 1.—The effect of agriculture on the number and average height of *Croton capitatus* Michx. plants per acre in 10 different fields for 6 successive years, College Station, Texas.

Field	1934			1935			1936			1937			1938			1939		
	Crop	Number per acre	Av. hght. in.	Crop	Number per acre	Av. hght. in.	Crop	Number per acre	Av. hght. in.	Crop	Number per acre	Av. hght. in.	Crop	Number per acre	Av. hght. in.	Crop	Number per acre	Av. hg't. in.
1	G	0		G	145	6	G	72	4	G	0		G	145	8	G	0	
2	G	0		G	0		P	1016	6	P	1742	6	P	8422	12	P	1597	10
3	G	145	4	G	0		Cr	1762	30	C	145	24	C	1016	18	C	0	
4	Cr	13213	28	C	12196	15	Cr	21635	36	C	726	28	Cr	3485	30	S	0	
5	C	1452	30	C	0		F	581	32	F	581	18	P	5445	18	P	5445	12
6	C.l.	0		C	145	40	F	2759	28	Cr	7405	18	F	4792	34	F	0	
7	C	145	30	F	8422	12	P	22070	18	Cr	9583	30	F	30492	18	P	36010	8
8	P	3194	12	P	9814	15	P	12923	10	P	18440	16	P	93509	12	P	35574	6
9	Cr	11616	30	F	24103	15	P	3775	15	C	0		Cr	1452	30	C	0	
10	C	3340	30	Cr	11035	28	C	0		Cr	2323	32	F	175402	12	P	9293	8

G—grass, P—pasture, F—fallow, C—cotton, Cr—corn, S—sorghum, C.l.—land from which timber was cleared during preceding years.

In field 1, which was in grass and ungrazed, the highest number of crotons per acre was 145 and the highest average height of plants was 8 inches and the plants averaged only 1 or 2 seed capsules. The effect of cultivation upon the croton in such a field is striking. Part of the above field was plowed and planted in cotton. *Croton capitatus* plants appeared scattered through the cotton. Some of these plants were over 60 inches high with many branches and seed capsules.

The variations in population following cotton and corn is illustrated in fields 4 and 10. In field 4 in 1935 there was a large croton population following cotton. This was because in this particular field all cultivation ceased by July 1. In these fields the plants reach the greatest average height. Field 10, fallow 1 year in 1938, had 175,402 crotons per acre. Field 2 shows the effect of grazing upon grassland. In 1934 and 1935 no croton was present but after 1935 when cattle were grazed in the field it became abundant. The effect of grazing upon abundance is more apparent in sandy soil and in open woods than in other locations.

Field 3 shows the effect of plowing up grassland and planting corn. In 1935 while the field was in grass no croton was present but in 1936 following corn the number per acre was found to be 1,762.

Field 8, which was pastured continuously for the six years, shows the wide variations in population in such fields. Fields 5, 6, 7 and 9 illustrate the variations in croton population in fields in which the general agricultural practice of the area is followed.

The rainfall of the region in which these studies were made was sufficient to allow for the development of large croton populations in some fields each year. For the five months April, May, June, July and August it varied from 26.39 inches in 1936 to 7.72 inches in 1937. It seems evident that in the fields studied the use made of the land has had more effect upon the number of crotons present than the amount of rainfall.

STUDIES OF PRIMROSES AND HORSEMINTS.—In addition to *Croton capitatus* there are numerous other plants which appear early in freshly disturbed soil, especially in fields allowed to lie fallow for a year. There are three of these species which are important in building up large flea hopper populations. These are the evening primrose, *Oenothera laciniata* Hill, *Oenothera speciosa* Nutt., and the horsemints, *Monarda* spp.

The evening primrose is, in the area in which these studies have been made, one of the favorite host plants of the flea hopper. It differs from croton in that it comes up in the fall and may often be found growing in fallow soil early in the spring before croton has come up. Its importance as an early season host plant is because of the following facts. When flea hopper eggs which have passed the winter in dead croton stalks hatch in the spring the nymphs drop to the ground and feed upon young croton plants if these are present. If not, then the nymphs must find other food plants very shortly or perish. *Oenothera laciniata* often grows under the dead stalks of croton and provides the nymphs with food. At College Station in 1936 flea hopper nymphs were found on February 23 on this plant. In the same field croton did not come up until nearly a month later. This evening primrose has another feature which makes it important as an early spring food plant. It grows in rosette form in the spring, its leaves spreading out nearly parallel with the ground. This forms an excellent protection for the nymphs, especially from heavy rain. Young croton plants with many first instar nymphs feeding on them before a rain have been found to have very few nymphs present after a heavy shower.

Another primrose, *Oenothera speciosa* Nutt., is abundant in old fields somewhat later in their progress toward the grass climax. It also grows especially well along ditch banks. During some years it covers large areas in both upland and bottomland fields. It is a favorite food of the flea hopper and is the first plant on which the author has found adult flea hoppers in the spring in the vicinity of College Station.

Horsemint (*Monarda* spp.), like croton, varies greatly in abundance from year to year. It is most abundant in fields that have been fallow for several years. It is also very common at times in open woods. Its fluctuations in abundance seem to be more closely related to rainfall than to variations in land use. In fallow fields under observation horsemint may be very scarce one year while the following year it

may occur in great abundance during May and early June. This plant differs from the primroses and crotons, so far as observed, in that it is more attractive to flea hoppers after it is well grown. Immense flea hopper populations develop on *Monarda* by late spring. As the plants mature the adult flea hoppers leave and may be dispersed by flight, assisted by the wind, over wide areas.

Each of the host plants of the cotton flea hopper discussed in this paper is native to Texas. Under natural conditions they were much less abundant than at present. Destroying the original vegetation in which grass is dominant allows these plants to increase without competition. This is true in a varying degree of all of the known host plants of the flea hopper. Such plants are most abundant on land in which the original climax vegetation has been destroyed. Agriculture, whether by breaking up the soil for planting crops or by grazing, greatly increases the host plants of the flea hopper (Bray, 1906).

From 1880 to 1920, the year in which the cotton flea hopper first "attracted attention as an economic pest" (Reinhard, 1926), the number of acres of cotton harvested in Texas increased from 2,473,000 to 12,323,000. From 1880 to 1920 the number of acres of corn harvested increased from 2,770,000 to 4,932,000 (Gabbard and Bonnen, 1937). This increase in planted acreage, especially that planted in corn, insured an increase in croton and other host plants of the flea hopper. From 1912 to 1920 there were also considerable fluctuations in the acreage planted to the above crops. While some of the land not planted to corn or cotton was planted to other crops a considerable amount of it must have laid fallow from one to several years. Again an opportunity was afforded for the increase of croton and of other host plants of the flea hopper.

It has been shown that croton increases under grazing. This is because the grass and some other plants are destroyed and the soil disturbed. This effect has been increasingly intensified as more and more grazing land has been fenced, confining more animals to smaller areas.

SUMMARY.—As previously stated, the first report of cotton flea hopper damage in Texas was in 1920. Since that year reports of damage have occurred every year from some locality in the cotton growing area of the state. Outbreaks of flea hopper damage can be explained in the following way. Due to the increase in agriculture the preferred host plants of the flea hopper have been enormously increased, thus insuring the maturing of correspondingly increased numbers of flea hoppers. As their preferred host plants begin to dry up in the late spring and early summer the mature flea hoppers disperse and, because of these increased numbers, more of them reach cotton. It is probable that the host plants of the flea hopper first became abundant enough to provide flea hoppers in sufficient numbers to injure cotton in 1920.

The preceding studies show the great variations in abundance due to variations in agriculture of *Croton*, the preferred host plant of the cotton flea hoppers. They show the part played by *Oenothera laciniata* in the development of an early spring generation of flea hoppers. They also show the importance of *Oenothera speciosa* and the *Monardas* in increasing the flea hopper populations. It is by means of similar studies carried on year after year that we can hope finally to be able to predict accurately when injury by the cotton flea hopper will occur.—1-6-40.

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SATIN MOTH infestations having been located in 1939 in the Oregon counties of Lane, Douglas, and Hood River, the State revised the quarantine effective April 26, 1940, to apply to these counties. The California quarantine proclamation No. 18 also was extended, effective March 9, 1940, to include these counties, and to place willow withes under restriction.

Soil Fumigation for Control of the Alfalfa Snout Beetle

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The alfalfa snout beetle, *Brachyrhinus ligustici* (L.), was probably introduced into Oswego County, New York, from central Europe about 40 years ago. There was little alfalfa in the area at that time and the insect apparently persisted in scattered plantings or on wild hosts until 1933 when it became numerous enough to attract attention. Meanwhile alfalfa had become a popular crop on the south shore of Lake Ontario. At present about 3,000 acres in Oswego and Jefferson counties are infested. The area is increasing annually though at a very slow rate due to the wingless condition of the beetle. The insect is, however, parthenogenetic so a single individual can start a new infestation. Because of this, small isolated infestations sometimes occur about the periphery of the major area. Occasionally these spots are found several miles from the continuously infested area. The insect is now a potential pest of alfalfa in much of northern and central United States and southern Canada.

The present investigation was begun to develop a system of soil fumigation which would eradicate the alfalfa snout beetle in these small isolated spots. If this can be done, the annual spread will be limited, practically, to the short distance the beetles can migrate on foot.

Extensive biological work by Palm (1935) and Lincoln (1938) has shown that the alfalfa snout beetle has a two year life cycle. Since the broods overlap, there are both adults and full grown larvae overwintering in the soil each winter. The adults leave the ground in April and oviposit in the surface soil about the roots of alfalfa plants. The young larvae feed on the roots and complete their development during their first summer. They pupate and emerge during June and July of the second summer, the beetles then remaining in the soil until the following spring. The adults may be found above the surface from April until late in August. It can readily be seen that soil fumigation as an eradication measure can be used only late in the summer or early in the fall since only then are all stages of the insect in the soil, and the soil temperature is still at summer level.

Procedure.—Plots of infested alfalfa ten feet square were used in all tests and the latin square plot arrangement was followed. Using crowbars, holes were bored fifteen inches apart in rows which were also fifteen inches apart, and the rows were staggered. Chloropicrin and methyl bromide were applied with the apparatus designed by Stark (1938). This consists of a 500 cc. distilling flask with side arm calibrated in cubic centimeters. The side arm is coupled to a three foot extension of glass tubing by means of a short piece of rubber tubing across which a pinch clamp operates. The extension is reinforced with a length of heavy wire which extends two inches beyond the lower end of the tube to prevent it becoming clogged with soil when the injections are made. The mouth of the flask is fitted with a one-hole rubber stopper containing a short piece of rubber tubing also closed with a pinch clamp. The other fumigants were measured in a graduate and poured through a glass funnel with a three foot reinforced extension on the stem. Immediately after placing the fumigant, each hole was filled with fine soil tamped in and sealed with about a half pint of water. No difficulty was experienced in applying any of the fumigants except methyl bromide. Because of the low boiling point of this material, it was found necessary to ice the steel cylinders for an hour before the fumigant could be poured into the dispensing flask. When put in the holes, it immediately began to fume and it is probable that a part of each injection was lost. This loss, however, must have been fairly uniform throughout the tests.

Results were taken by counting live and dead larvae and adults found by screening the soil taken from a hole two feet square and eighteen inches deep in the center of each plot.

The first test was made on a 6×6 latin square using chloropicrin, carbon bisulphide, carbon tetrachloride, orthodichlorobenzene, and dichlorethyl ether. The alfalfa on this block was only a year old and the infestation consisted entirely of larvae. Since the larvae were for the most part near the surface, injections were

made at the six inch level. Results obtained are shown in table 1. Analyses of the data show that for significance, a difference of 18.59 per cent in kill was required at odds of 19 to 1 and 28.17 per cent at 99 to 1. On this basis highly significant kills were obtained with carbon disulphide, chloropicrin, and carbon tetrachloride. However, since a material was being sought which could be depended upon for eradication, only the carbon bisulphide, which caused a complete kill could be considered satisfactory. The low kill obtained with orthodichlorobenzene and dichlorethyl-ether was due in part

Table 1.—*Brachyrhinus ligustici* (L.) Control of larvae obtained by soil fumigation. Oswego, New York, September 2, 1939. Soil temperature 70.7 degrees F. at 8 inches depth. Moisture 6.56 per cent at 6 inches.

Fumigant	Hole Dosage	Approximate Acre Dosage	Per Cent Mortality	Soil Moisture
Chloropicrin	3 cc.	400 lbs.	88.5	6.56% at 6 inches
Orthodichlorobenzene	36 cc.	3737 lbs.	9.5	
Carbon tetrachloride	36 cc.	4473 lbs.	41.4	
Carbon disulphide	36 cc.	3540 lbs.	100.0	
Dichloroethyl-ether	15 cc.	1440 lbs.	7.8	
Check	—	—	1.9	

Difference for significance at 99 to 1 = 28.17.

to their slowness of action. The first counts of live and dead larvae were made within six days after treatment. A second count made approximately four weeks after treatment showed 79 per cent of dead larvae on the orthodichlorobenzene plots, or an increase of nearly 70 per cent, and 53 per cent of dead larvae on the dichlorethyl-ether plots, or an increase of 45 per cent. At this time there was still a strong odor of these two materials coming from the soil.

Orthodichlorobenzene was the only material which caused immediately noticeable injury to the alfalfa. When last examined, about 70 days after treatment, all vegetation on the orthodichlorobenzene plots appeared dead. On the others, including the chloropicrin plot the alfalfa apparently was in good condition.

The second test was made on a 4×4 latin square on older alfalfa which was well infested with both larvae and adults. Chloropicrin, carbon bisulphide and methyl bromide were used and injected at the one foot level since the adults were at about this depth. Counts made within a week after treatment gave the results

Table 2.—*Brachyrhinus ligustici* (L.) Control by soil fumigation. Soil moisture 11.1 per cent, temperature 62.3 degrees at 4 inches depth. Henderson, New York, Sept. 12, 1939.

Fumigant	Dosage		Per Cent Mortality	
	Per Hole	Per Acre	Larvae	Adults
Methyl Bromide	7 cc.	953 lbs.	100.0	94.1
Carbon bisulphide	36 cc.	3540 lbs.	100	100
Chloropicrin	3 cc.	400 lbs.	31.5	100
Check			1.02	2.6

Difference for significance at 99 to 1; larvae, 58.93; adults 64.45.

shown in table 2. Analysis of the data shows that for the larvae a difference of 58.9 per cent is necessary for significance at 99 to 1 and for the adults 64.4 per cent. From the point of view of eradication only carbon bisulphide was effective since it alone gave a 100 per cent kill of both larvae and adults.

The next step was to determine the lowest dosage of carbon bisulphide which could be used for eradication. A 4×4 square was treated with carbon bisulphide at three rates, 35 cc., 18 cc., and 9 cc. The area on which this test was made contained old alfalfa infested with both larvae and adults. Results obtained are shown in table 3. A similar test was made with methyl bromide using dosages of 7 cc., 4 cc., and 2 cc., injected at a depth of 8 inches. Because of the reputed slow action of this fumigant, counts were postponed until ten days after treatment. Each of these dosages killed one hundred per cent of the adults, but none of them killed all the larvae, as is shown in table 4.

In the fifth block, three methods of applying chloropicrin were tested. The first consisted of a standard 3 cc. application in holes 15 inches apart and eight inches deep which were closed with fine

Table 3.—*Brachyrhinus ligustici* (L.) Control of larvae by fumigation with carbon disulphide. Henderson, New York, September 19, 1939. Soil moisture 6.88 per cent and temperature 58.3 degrees at 4 inches depth.

Fumigant	Dosage		Per Cent Mortality
	Per Hole	Per Acre	
Carbon disulphide	36 cc.	3540 lbs.	100
Carbon disulphide	18 cc.	1770 lbs.	98.4
Carbon disulphide	9 cc.	885 lbs.	78.3
Check	—	—	10.9

soil. The second was the same except that the holes were tamped shut. In the third treatment the same amount of chloropicrin was applied per acre but in holes only 10 inches apart. None of these treatments killed all the larvae, and adults were too few in this block to yield usable data.

Table 4.—*Brachyrhinus ligustici* (L.) Control of larvae by fumigation with methyl bromide. Oswego, New York, October 9, 1939. Soil moisture 15.2 per cent at 6 inches; temperature 57.7 degrees at 8 inches.

Fumigant	Dosage		Per Cent Mortality
	Per Hole	Per Acre	
Methyl bromide	7 cc.	935 lbs.	94.2
Methyl bromide	4 cc.	544 lbs.	81.6
Methyl bromide	2 cc.	272 lbs.	76.7
Check	—	—	13.8

The failure of chloropicrin in this test may have been due to the higher soil moisture.

On October 30, with soil temperatures between 40 degrees and 45 degrees F., a block of 8 plots 10 feet square were used to test the effectiveness of carbon bisulphide at low soil temperatures. A dosage of 35 cc. per hole was used in holes 15 inches apart and eight inches deep. A complete kill of both larvae and adults in the four treated plots resulted. Adults again were few but since all data has indicated that they are more easily killed than larvae, it is probable that any number present would have been killed.

The cost of fumigation with any of the effective materials is high. Chloropicrin costs slightly over $340.00 an acre at a dosage of 400 pounds per acre. Methyl bromide costs over twice as much because of the larger dosage required. Carbon bisulphide when used at a dosage of 2,500 pounds per acre costs about $250. These figures are for materials alone. Approximately 40 man days are required to treat an acre with carbon disulphide.

Summary.—The alfalfa snout beetle, *Brachyrhinus ligustici* (L.), is an introduced pest now present in 3,000 acres of alfalfa in Oswego and Jefferson counties, New York. Isolated spots of infestation removed several miles from the continuous area sometimes appear. For eradicating beetles and larvae in these spots soil fumigation has been found effective.

Preliminary tests with carbon bisulphide, chloropicrin, methyl bromide, carbon tetrachloride, dichlorethyl-ether, and orthodichlorobenzene indicate that only carbon bisulphide can be depended upon to eradicate both larvae and adults under the various weather and soil conditions encountered in northern New York.

Approximately thirty-five hundred pounds of carbon bisulphide per acre injected in holes 15 inches apart and eight inches deep has given a complete kill in all tests. Eighteen hundred pounds per acre gives a nearly complete kill, and it is believed that a dosage of 2,500 pounds per acre will prove to be completely effective. —1-6-40.

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A Method for Production of Cutworms in Greenhouses

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In order to secure cutworms in sufficiently large numbers and of satisfactory uniformity for toxicological studies in the laboratory the following method has been devised and used with good results. The rearing cages consist of greenhouse benches approximately 4 feet by 12 feet in size, with walls 12 inches in height built up from the top of the bench having a 2-inch wooden flange extending inward from the top of the wall. This frame is fitted with a hinged screen wire top. A bench can be divided in the middle to furnish two separate rearing compartments. Since the rearing methods are somewhat different for the species of cutworms that have been used in the experiments, the methods employed for each species will be discussed separately.

Small grains, preferably oat seedlings,

have been found to be the best food for *Leucania unipuncta* (Haw.). Moths or pupae are placed in a cage with oat seedlings from four to six inches in height. A five per cent honey solution added to a sponge is present in the cage as food for the moths. Eggs are deposited freely on the oat plants, and after hatching the young larvae obtain sufficient food from the seedlings to carry them through the first three or four instars. After that time oats or corn from other beds is cut and fed daily to the larvae. When excrement pellets cover the surface of the bed, a thin layer of sand can be sprinkled over the surface before feeding. The larvae to be used as breeding stock are allowed to pupate in the beds. After being removed from the soil, the pupae are placed in a tray filled with moist sphagnum and allowed to emerge normally in a new rearing cage.

This same method of placing the moths in the rearing cage did not prove satisfactory for *Agrotis ypsilon* (Rott). With this species the moths were placed in battery jars partially filled with small sticks of wood and covered with muslin caps. Paper toweling on the bottom of the jars furnished desirable hiding quarters for the moths during the day. The eggs were deposited on the sticks and on the caps. The eggs were transferred to beds planted to rape, turnips, or sweet clover. If it was necessary to use eggs deposited over a period of days, those deposited first were placed in a refrigerator and kept until all eggs were introduced in the beds at once. This procedure was advisable to secure larvae of uniform size and thus reduce cannibalism to a minimum. Rape foliage cut daily was fed to the larvae after they consumed the plants growing in the rearing cages. Lettuce trimmings from the grocery store served as a readily available source of food when the greenhouse supply was exhausted. Pupae were handled as already described for *L. unipuncta*.

Graphiphora c-nigrum (L.) was reared in the same way as *A. ypsilon*. This species, however, is not cannibalistic to any noticeable extent.

The problem of watering the rearing beds without injuring the young larvae was met by allowing the water to run from the hose over the surface of the bed without wetting the plants. Watering usually was done at night when the larvae were on the plants, feeding. After discarding a rearing cage, the soil was treated with 1 per cent formalin solution to prevent damping off of the next crop of oat seedlings. This treatment may possibly have had some effect in keeping disease among the larvae at a low level. Occasional dead larvae were removed from the cages as soon as noticed. In the experience of the authors the rearing cage described is large enough to produce 5,000 or more larvae of *L. unipuncta*. As large a number of *A. ypsilon* cannot be reared because of cannibalism among the larvae.

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Commercial Control of Cabbage Caterpillars near Charleston, S. C.

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In a survey of various commercial cabbage fields near Charleston, S. C., during the period from 1935 to 1938 observations were made on the methods of insecticidal control used by the different growers and the relative effectiveness of the treatments. These observations were a part of a detailed study of cabbage caterpillar populations and the effect of such populations on the quality and quantity of the crop.

PROCEDURE.—In the vicinity of Charleston the growing of cabbage covers

* Thanks are due W. J. Reid, Jr., for his assistance in the direction of this study.

† In cooperation with the South Carolina Agricultural Experiment Station.

two seasons which somewhat overlap. The fall crop is planted in the fields during late July, August, and September and is harvested during late November, December, and January. The winter-spring crop is planted in seed beds in October and November, transplanted into the fields in December, January, and February, and harvested in March, April, May, and early June. During each of the four cabbage-growing seasons from the fall of 1935 to the spring of 1937 five fields near Charleston were studied; also, two such fields were studied in the fall of 1937, three in the winter-spring season of 1937–38, and one in the fall of 1938, making a total of 26 fields. Seven of these were grown at the South Carolina Truck Experiment Station and will not be considered in evaluating control. The remaining 19 fields were grown by 16 different commercial growers and well represent the practices in the Charleston area.

In each field two blocks of 100 plants each were located at random. Each block consisted of four adjacent rows of 25 plants each. Each plant was designated by a number and examined each week from the time of thinning or transplanting until it was harvested.

Records were made of the number of pupae and mature larvae of each of the following insects, which are listed in order of relative abundance: Diamondback moth (*Plutella maculipennis* (Curt.)), cabbage looper (*Autographa brassicae* (Riley)), imported cabbage worm (*Pieris rapae* L.), cutworms and related species of the subfamily Agrotinae including the corn earworm (*Heliothis armigera* (Hbn.)), and the cabbage webworm (*Hellula undalis* (F.)). The cabbage webworm was of little importance except just before the plants were thinned or transplanted. At each examination of the plants the mature larvae of the Agrotinae and cabbage webworm were removed, since they pupate in the soil, but only the pupae of the other species were removed.

Each plant was harvested when it became mature and was classified according to the specifications for U. S. Grade No. 1 and, for insect damage, as described by the Bureau of Agricultural Economics, U. S. Department of Agriculture (1934). Those plants ineligible to U. S. Grade No. 1 because of defects other than insect damage and which usually did not produce heads will be considered as irrelevant to this discussion. The remaining plants which were individually eligible to U. S. Grade No. 1 were classed as marketable, and those which were so damaged by insects as to prevent them from being or becoming eligible to U. S. Grade No. 1 were classed as unmarketable or damaged.

INSECTICIDES.—The insecticides included derris,[1] calcium arsenate, lead arsenate, magnesium arsenate, Paris green, and cryolite. Usually the materials were applied as dusts, but on some fields cutworm baits were used. Some of the insecticides were used undiluted and others were diluted with clay or lime. Some were mixed with each other. Derris was mixed with clay to contain about 0.75 per cent of rotenone. The mixtures were made up largely according to the whim or fancy of the grower himself or, more often, acording to that of the local insecticide dealer from whom the grower made his purchases.

As a whole the insecticides were applied to the crop whenever the grower saw considerable evidence of insect injury, provided the current prices for cabbage warranted its protection from insects. A few growers made more or less regular applications every week or 10 days as long as the larvae were fairly numerous in the field. Cutworm-bait applications were made, particularly in the fall, when numerous evidences of injury to the young plants appeared.

Cutworm baits usually were scattered broadcast over the field. On one occasion in a field of larger plants the bait was placed by hand between the rows and beneath the plants in order to avoid leaving arsenical residue on the plants. At another time bait was applied directly in the head of the plants in an attempt to kill cabbage loopers as well as cutworms. The dust mixtures usually were applied with traction dusters. The care with which the various machines were adjusted was as individual as the different growers or as the cheap labor which they sometimes employed. Occasionally the dust mixtures were applied by hand by sifting through small, loosely woven bags.

RESULTS.—It was noted that the insect

[1] Although the term "derris" is used in this article, there is evidence that the powder used by some of the growers contained other rotenone-bearing roots such as cubé.

populations varied according to the time of year when the crop was grown and the stage of growth of the plants in the particular field. Hence, to permit accurate comparison, the data were grouped with respect to these two factors. A uniform stage of growth for all fields was when was found that the diamondback moth caused an average of about 25 per cent as much damage per individual as did the other species. Since the relative damage caused by the other species could not be satisfactorily determined from the available data, those species were given equal

Table 1.—Data obtained in cabbage caterpillar survey of commercial fields. Charleston, S. C., 1935–38.

Field Number	Date of Heading*	Insecticide and Number of Applications		Average Number of Caterpillars Maturing per 100 Plants†	Plants Damaged	Loss in Yield, Tons per Acre
		Before Heading	After Heading			
			Fall season			
3E-1	Sept. 22, 1936	Derris 3	Arsenical 1, derris 4	61	25%	2.31
3E-4	Sept. 28, 1936	Arsenical 3	Arsenical 3, derris 3	50	14	1.06
3E-3	Oct. 1, 1936	Arsenical 1	Arsenical 4, derris 1	65	7	.96
5E-1	Oct. 1, 1937	Poisoned bait 2, arsenical 3	Arsenical 2	46	9	.99
3E-2	Oct. 2, 1936	Arsenical 3	Derris 5	106	11	1.01
7E-1	Oct. 6, 1938	Arsenical 1, cryolite 3	None	60	19	2.40
1E-1	Oct. 9, 1935	Arsenical 1	Derris 4	148	47	.95
5E-2	Oct. 12, 1937	Poisoned bait 3, arsenical 1	Poisoned bait 1	23	4	.43
1E-4	Oct. 14, 1935	Arsenical 2	Arsenical 2	142	38	1.32
1E-2	Oct. 15, 1935	Arsenical 2	Arsenical 1, derris 3	34	12	.60
1E-3	Oct. 15, 1935	Poisoned bait 3	Poisoned bait 1	101	24	1.10
			Average	76	19	1.19
			Winter-spring season			
6E-1	Feb. 25, 1938	None	None	62	6	.40
4E-2	Mar. 11, 1937	None	None	116	3	.32
2E-1	Mar. 12, 1936	None	None	20	2	.11
6E-2	Mar. 23, 1938	None	None	793	49	5.95
4E-1	Mar. 24, 1937	None	Derris 1	124	6	.72
4E-3	Apr. 7, 1937	Derris 1	Derris 3	176	21	1.36
2E-3	Apr. 14, 1936	None	Derris 1	543	63	3.34
2E-4	Apr. 16, 1936	None	None	344	32	3.24
			Average	272	23	1.93

* When first plants in individual fields began to head.
† Weighted average.

heading of the plants began. This date, as will be shown, was important in regard to the relative amount of damage caused by the insect populations and also to the insecticidal residue problem in relation to harvest (Smith *et al.* 1937).

The data obtained from this survey are given in table 1. In obtaining the averages in column 5 the larvae of the diamondback moth were given a weight of 0.25. This weight was determined from a multiple correlation analysis in which it weight in obtaining the averages. The per cent loss in unmarketable plants is only of that part of the crop which would have produced marketable cabbage except for larval damage and not of the whole crop. The loss yield represents the product of the number of unmarketable plants and the average weight of the marketable ones.

DISCUSSION OF RESULTS.—With the fall crop the period during which plants began to head extended over approxi-

mately 5 weeks, from September 22 to October 25, and with the winter-spring crop this period extended over approximately 7 weeks, or from February 25 to April 16. The longer transplanting period of the winter-spring crop may account for this difference in time.

The applications were much more numerous on the fall crop than on the winter-spring crop. Ten of the 11 fields of the fall crop received arsenical or bait treatments before heading of the plants began, but not one of the eight fields of the spring crop received such treatments. In the fall plantings *Agrotinae* and cabbage webworms were prevalent, but the winter-spring plantings matured before the caterpillar populations developed in damaging numbers. The survey involved a relatively small portion of the commercial spring plantings. Fewer larvae matured on the plants of the fall crop than on those of the winter-spring crop, partly, at least, because of the greater number of applications. The species found on the winter-spring crop were mostly the diamondback moth, the cabbage looper, and the imported cabbage worm.

In the fall crop the percentage of damage by insects tended to decrease as the heading season advanced, whereas in the winter-spring crop the opposite was true. The unmarketable plants in the various fall fields ranged from 4 to 47 per cent, with an average of 19 per cent, and in the winter-spring fields from 2 to 63 per cent, with an average of 23 per cent. It will be seen that as a whole the damage was rather serious in spite of the growers' efforts and that more adequate control measures were needed. The losses per acre in tons of unmarketable cabbage may be used in estimating monetary losses. The average yield of marketable cabbage was approximately 7.07 tons per acre for the fall crop and 6.59 tons per acre for the winter-spring crop.

In order to obtain accurate comparisons of treatments there should be replications. In the fall surveys there was not one replication among the 11 fields represented, as each grower used a different schedule of applications. In the winter-spring fields there were a number of seasonal or yearly replications of untreated fields. Fields 4E-1 and 2E-3 each had one application, but in the former it was 3 weeks earlier than in the latter; and moreover field 2E-3, with 63 per cent damage, had been planted beside a field of old fall-grown cabbage from which it received an unusually heavy infestation of the diamondback moth. Field 6E-2, which had a loss of 49 per cent as early as March 23, was planted beside a field of fall-grown cabbage that had already acquired a moderately heavy infestation, particularly of the diamondback moth; and the grower did not think he could afford to apply insecticides because of the low prices being received for the crop.

Good control was obtained in field 5E-2, in which there was a lower percentage of damage and a smaller caterpillar population than in other fields of approximately the same seasonal development.

Other points might be considered with regard to comparisons of different treatments, but there was not a sufficient number of replications of any given treatment on comparable plantings to permit accurate comparisons. The surveys were not originally designed for the purpose of testing insecticide applications.

SUMMARY.—As a part of a detailed survey, during the period 1935 to 1938, of cabbage caterpillar populations in fields near Charleston, South Carolina, a study was made of the control methods used by the different commercial growers and their effectiveness. During the fall growing season 11 fields were studied and during the winter-spring season 8 fields. Weekly examinations were made of 200 plants in each field from the time of thinning or transplanting until harvest was completed, and records were kept of insecticidal applications and methods, caterpillar populations, and harvest yields.

Although insecticides were applied at regular intervals by a few of the growers, they were usually applied only when the grower saw considerable evidence of insect injury. Arsenical and other inorganic insecticides were used during the preheading stage in all except one of the early fall fields, but none of the winter-spring fields received such treatments. There was not a sufficient number of replications of any given treatment on comparable plantings to permit accurate comparisons.

The average number of larvae maturing per 100 plants was 76 in the fall crop and 272 in the winter-spring crop. Plantings in close proximity to fields with older

infestations developed larger insect populations and showed a greater number of damaged plants than were to be found in other plantings.

The damage due to cabbage caterpillars in commercial fields ranged from 2 to 63 per cent of the plants, with an average of 19 per cent for the fall season and 23 per cent for the winter-spring season. The study indicated that as a whole the damage was rather serious in spite of the growers' efforts and that there was a need for more adequate control measures. —1-6-40.

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Host Plants of the Tobacco Flea Beetle

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Surveys were made and rearing experiments conducted in Pittsylvania County, Virginia, in 1939 in order to determine the host plants of the adults and the larvae of the tobacco flea beetle, *Epitrix parvula* (F.), and their importance in maintaining or increasing the beetle population in Virginia.

Metcalf & Underhill (1919), Morgan & Gilmore (1924) and Hallock (1939) have recorded a total of 37 host plants of the adult tobacco flea beetle but they consider only those of the family Solanaceae to be important. Chittenden (1898, 1899), Howard (1898) and Jewett (1926) reared or observed the immature stages on the roots of tobacco (*Nicotiana tabacum*), jimson weed (*Datura stramonium*), black nightshade (*Solanum nigrum*), tomato (*Lycopersicon esculentum*), and horse nettle (*Solanum carolinense*). Howard (1898), Metcalf (1909) and Chittenden (1923) believed that this insect could develop and thrive on any solanaceous plants.

FIELD SURVEYS.—During April and May, tobacco flea beetles were observed feeding on the following plants: tobacco (*Nicotiana tabacum*), potato (*Solanum tuberosum*), black nightshade (*S. nigrum*), horse nettle (*S. carolinense*), tomato (*Lycopersicon esculentum*), jimson weed (*Datura stramonium*), ground cherry (*Physalis heterophylla*), turnip (*Brassica rapa*), burdock (*Arctium lappa*), giant ragweed (*Ambrosia trifida*), cocklebur (*Xanthium canadense*), string bean (*Phaseolus vulgaris*), and pokeweed (*Phytolacca decandra*). They were found mostly in tobacco plant beds where they fed on tobacco seedlings and young tomato plants, a few of which were grown in many beds. They were also observed on potato and on most solanaceous weeds when the plants first appeared in the spring. They were found feeding freely on burdock plants near one plant bed, but in other localities there were few beetles on this weed. Some beetles occurred on turnip, giant ragweed, cocklebur, pokeweed, string bean and chickweed, but there was little evidence of feeding.

There was a definite migration of beetles from the above sources to the tobacco plants when the latter were set in the field. The insects could be found in small numbers, however, throughout the season, in plant beds and on potato plants until the vines died. They were also found throughout the season on jimson weed but were seldom found on other solanaceous weeds growing outside of the tobacco fields. The population of beetles in the tobacco fields increased from less than one beetle to about 70 per plant during the late spring and summer.

About the first of August and soon after the harvesting of the crop was begun the flea beetles began leaving the tobacco fields. As harvesting progressed more and more beetles left the fields until by the middle of September there were comparatively few left on tobacco. The beetles scattered over cultivated fields, meadows,

* The writer gratefully acknowledges indebtedness to Prof. A. B. Massey for identifying the weeds referred to in this investigation.

pastures, and woodlands and fed on a great variety of plants. The following solanaceous plants were severely attacked: tobacco, black nightshade, potato, horsenettle, jimson weed, tomato, ground cherry (*Physalis heterophylla*, *P. angulata*, *P. lanceolata*, *P. pruinosa*), egg plant (*Solanum melongena*) and pepper (*Capsicum annuum*). Following is a list of plants on which the flea beetles were found occasionally and on which they fed sparingly in the late summer and fall:

Phytolacca decandra
Arctium lappa
Xanthium canadense
Ambrosia trifida
Solidago altissima
Solidago juncea
Erechtites hieracifolia
Eupatorium album
Gnaphalium polycephalum
Ipomoea hederacea
Ipomoea purpurea
Ipomoea pandurata
Ipomoea coccinea
Ipomoea batatas
Celtis mississippiensis
Vigna sinensis
Phaseolus vulgaris
Lespedeza bicolor
Lespedeza cyrtobotyra
Lespedeza juncea
Lespedeza virginica
Pueraria thunbergiana
Portulaca oleracea
Passiflora incarnata
Asclepias tuberosa
Brassica rapa
Tecoma radicans
Amaranthus sp.
Rubus villosus
Rubus sp. (blackberry)
Zea mays

The beetles were found occasionally on the foliage of the following trees: oak, sourwood, maple, hickory, black locust, sumac, wild plum, yellow pine and white pine.

WEED AND BEETLE COUNTS.—Thirteen tobacco fields representing two soil types, having different degrees of slope, located in three localities and surrounded by various types of vegetation were selected for beetle and weed counts. The beetles were counted on 25 tobacco plants selected at random but evenly scattered over each field. Counts of solanaceous weeds were made in June, both inside and outside the fields. In the fields the weeds were counted in several rows of tobacco. Outside each field but within 100 feet of the borders a 10-foot string with a weight attached at each end was tossed at random and the weeds within 1 foot of the string were counted. This operation was repeated twenty times for each field. The numbers of weeds were calculated to show the number per 100 square yards.

Only three solanaceous weeds were encountered in the weed counts. The number of weeds per 100 square yards and the species were as follows: horsenettle, 7 inside the fields, 35 outside; ground cherry (*P. heterophylla*), 0.2 inside, 0 outside; and black nightshade, 0.1 inside, 1.3 outside.

Of the cultivated solanaceous plants only the potato and tomato were present on many of the farms. Most farmers planted one or two potato patches in the vicinity of tobacco fields in the early spring. The potatoes generally came up about the time the beetles emerged from hibernation. A few tomato plants were generally set out about the time the tobacco plants were set in the field.

Figure 1 shows the results of beetle counts made in two fields, one of which

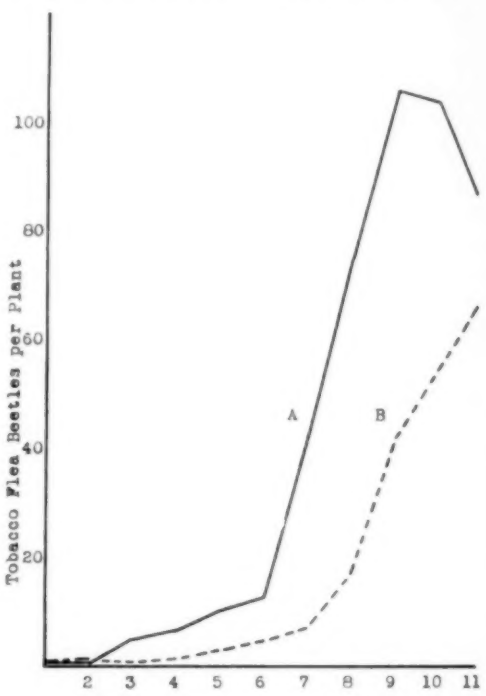

FIG. 1.—The tobacco flea bettle populations in two fields, one with two tobacco plant beds and the other with two potato patches on their border (A); and in eleven fields with neither plant beds nor potatoes in the vicinity (B).

had two tobacco plant beds beside it and the other, two potato patches, and in 11 fields which had no tobacco plant beds or potatoes nearby. In the former there was a decided increase in the beetle population at the third week, but in the latter no increase came until the fourth or fifth week. It was apparent that the increase in the beetle population in the former fields was due to beetles that had begun to develop in the plant beds or potato

patches before the tobacco plants were set in the field. It can also be seen from the figure that after the third week the beetle population increases were parallel, but that the former was about two weeks ahead of an nearly twice as large as the latter.

REARING EXPERIMENTS.—Plants upon which the adults of the tobacco flea beetle were known to feed were planted in a small plot of land with the type of soil commonly used for tobacco. Twenty-six species of plants representing 11 families were used. Beetles were caged on the plants in cages made of muslin supported by metal frames (Fig. 2). Thirty beetles were placed in each cage and were left for four days and then removed. The tops of the cages, which were removed at this time, were left off for 16 days and then replaced. During the next 23 days daily examinations were made for emerging beetles. The beetles used in all the tests of a series were collected at one time from the same locality and were placed in a common container, from which they were transferred to the cages in lots of 30 each. It was believed that by this method the proportion of the sexes and other conditions as regarded the beetles used would be approximately the same in all tests. In order to determine whether or not the beetles were depositing eggs during the time that they were caged, 30 of the beetles from each collection were placed in an oviposition cage and observed for oviposition.

RESULTS.—Eggs were deposited by the beetles in all the check cages for the different series. No beetles developed, however, on any of the non-solanaceous plants tested. These included the following plants: *Rumex acetosella*, *Phytolacca decandra*, *Stellaria media*, *Brassica rapa*, *Brassica oleracea*, *Rubus* sp., *Vigna sinensis*, *Phaseolus vulgaris*, *Viola fimbriatula*, *Oenothera biennis*, *Ipomoea pandurata*, *Erigeron* (2 spp.), *Ambrosia trifida*, *Arctium lappa*, and *Xanthium canadense*. Beetles developed on all the solanaceous plants tested, tobacco, jimson weed, and potato being by far the most important host plants (Table 1).

Table 1.—Number of tobacco flea beetles emerging in cage tests.

PLANT	NUMBER OF TESTS	BEETLES EMERGING	
		Total	Average
Tobacco	8	206	25.8
Jimson weed	7	172	24.6
Potato	6	139	23.2
Tomato	7	55	7.9
Black nightshade	7	22	3.1
Horsenettle	7	9	1.3
Ground cherry (*P. heterophylla*)	7	3	0.4
Pepper	6	2	0.3
Ground cherry (*P. pruinosa*)	3	23	7.7
Egg plant	3	11	3.7

FIG. 2.—Cages over plants used in rearing experiments.

DISCUSSION.—These studies indicate that in Pittsylvania County wild host plants were of minor importance during 1939 in building up the infestation of tobacco by the tobacco flea beetle. Although the adult beetles fed on a number of wild plants, their inability to multiply on any but those of the family Solanaceae and the scarcity of the members of that family in the vicinity of tobacco fields minimize their importance. Few beetles could be found on horsenettle, the only weed sufficiently abundant to receive consideration, and there was no correlation between the presence of this weed and the infestation of tobacco plants in nearby fields.

The potato is the only cultivated solanaceous plant that occurred in the field early enough in the spring to be of importance as a host of the tobacco flea beetle before the tobacco was set. Rearing studies showed that the insect reproduced almost as readily on potato as on tobacco. Since potatoes were grown frequently in the vicinity of tobacco fields, therefore, it would be assumed that the potato might be of importance in increasing the

infestation in these fields. Observations indicated that this was true. In tobacco fields with potato patches nearby, new generation beetles appeared first on tobacco plants next to the potato patches, in some cases before there had been sufficient time for the beetles to develop on tobacco plants after they had been set in the field.

SUMMARY.—In the spring, adult beetles were found feeding on 13 hosts; during the growing season, they occurred principally on tobacco; and in the late summer and early fall 52 host plants were recorded.

The insect was reared on all plants of the family Solanaceae tested, but not on 16 species of plants representing 10 other families. The beetles developed most readily on tobacco, potato, and jimson weed.

Tobacco plants in the bed and potato in the field were important in building up the beetle population in nearby fields in the spring before the tobacco plants were set in the field.—1-6-40.

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Migration of the Tobacco Flea Beetle

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A study of the migration habits of the tobacco flea beetle, *Epitrix parvula* (F.) was made at Chatham in 1939. Observations were made from the time the beetles began emerging from hibernation in the spring until they began entering hibernation in the fall.

FIG. 1.—Adhesive screen of the type used in the migration studies.

METHOD OF STUDY.—Screens 1 foot wide and 6 feet high were constructed of lattice strips and covered with 20-mesh copper wire cloth. The wire cloth was coated with tree tanglefoot so that a smooth, adhesive surface was presented on each side. Each screen was placed in an upright position 6 inches from the ground at a selected location (Fig. 1). Beetles caught on the faces of the screens were removed and counted at intervals of 2 or 3 days. The counts were made so as to give the number of beetles captured on each side of the screens and at different heights.

MIGRATION UPON EMERGENCE FROM HIBERNATION.—On March 15, three screens were placed at intervals of 40 feet and at a distance of 20 feet from the edge of a wooded area adjacent to a tobacco field where beetles were known to have been abundant late the preceding fall. The screens were left until May 30, at which time most of the overwintering

insects had died out. The data obtained show that the beetles of the hibernating brood were active from the latter part of March until the last of May and that the period of greatest activity was the last week in April. The largest number of beetles was captured on the side of the screen facing the wooded area and at a height of 2 to 4 feet (Table 1). It is apparent that many of the beetles had hibernated in the litter along the edge of the wooded area.

Upon emergence from hibernation the tobacco flea beetles immediately migrate to available food plants. In the early spring they were first found feeding on tobacco and other host plants near tobacco beds and in the vicinity of favorable hibernating quarters.

Table 1.—Tobacco flea beetles captured and their positions on three adhesive screens located along the edge of a wooded area adjacent to a tobacco field, March 17 to May 30.

	Number of Beetles on Screens				
	Facing		At Heights* of—		
Screen Number	Tobacco Field	Facing Woods	1–2 Feet	2–4 Feet	4–6 Feet
1	63	78	13	77	51
2	55	76	36	64	31
3	60	78	33	88	17
Total	178	232	82	229	99

* Height from bottom of screen which was 6 inches from the ground.

MIGRATION TO TOBACCO PLANTS.—A small square plot of about one-third of an acre of newly set tobacco plants located in the center of a grassland area was selected, and on May 15 a screen was placed at the middle of each side of the plot and about 10 feet from the tobacco plants. The data show that there was a definite movement of the beetles from the direction of the grassland to the tobacco plants (Table 2). It was noted at this time that there was a decrease in the number of beetles in plant beds and on other host plants.

More injury was observed on tobacco plants which were near potato patches. Apparently the beetles emerged from hibernation and fed on the potato which is known to be a food plant of the tobacco flea beetle. It is evident that a brood may develop on potato and the adults migrate to nearby tobacco fields. Morrill & Lacroix (1937) found that the potato flea beetle, *Epitrix cucumeris* Harr., seemed to fly from potato to tobacco.

Table 2.—Tobacco flea beetles captured and their positions on four adhesive screens located around a field of newly set and growing tobacco plants, May 17 to July 12.

	Number of Beetles on Screens				
	Facing Newly Set Plants	Facing Grassland	At Heights* of—		
Screen Number			1–2 Feet	2–4 Feet	4–6 Feet
1	1	17	4	13	1
2	1	11	0	8	4
3	2	15	1	13	3
4	3	15	3	14	1
Total	7	58	8	48	9

* Height from bottom of screen which was 6 inches from the ground.

MIGRATION DURING SUMMER AND FALL.—On July 9 two adhesive screens were erected 30 feet apart and 20 feet from the border of a tobacco field one-third of an acre in area and 125 feet from another tobacco field 1 acre in area. More beetles were captured on the fronts of the screens facing the larger field (Table 3). The flea beetle population, however, was larger per unit area in the smaller tobacco field than in the larger field. The tobacco in the smaller field was never primed, and it is likely that the beetles collected there when the tobacco in the larger field was primed. The harvesting operation consists of the removal of the lower leaves as they ripen and is referred to as priming.

On July 15 four adhesive screens were erected at intervals of 40 feet in the center of a strip of grassland 150 feet wide between two tobacco fields, one field containing about 10 acres, the other, 3

Table 3.—Tobacco flea beetles captured, and their positions, on two adhesive screens located between two tobacco fields, July 11 to September 16.

	Number of Beetles on Screens				
	Facing Small Field	Facing Large Field	Height,* in Feet		
Screen Number			1–2	2–4	4–6
1	178	289	119	226	122
2	207	811	306	495	217
Total	385	1100	425	721	339

* Height from bottom of screen, which was 6 inches from the ground.

Table 4.—Tobacco flea beetles captured, and their positions, on four adhesive screens located between two tobacco fields, July 18 to September 16.

Screen Number	Number of Beetles on Screens				
	Facing 10-Acre Field	Facing 3-Acre Field	Height,* in Feet		
			1–2	2–4	4–6
1	525	678	459	460	284
2	738	662	459	602	339
3	272	167	110	212	117
4	1456	1190	782	1256	608
Total	2991	2697	1810	2530	1348

* Height from bottom of screen, which was 6 inches from the ground.

acres. The results indicate little migration of the beetles in July and August but a decided movement in September. The stalks and suckers had been cut on August 31 and this apparently accounted for the increase in migration. There was little difference in the numbers of beetles taken on the two sides of the screens, but, as in the other tests, most beetles were taken at the height of 2 to 4 feet on the screens (table 4).

The numbers of beetles gradually decreased in all tobacco fields examined, and by September 10 very few were found on tobacco plants.

ELEVATED ADHESIVE SCREENS.—On September 6 two adhesive screens were erected on a pole 24 feet high. The upper screen extended from 18 to 24 feet in altitude and the lower screen from 11 to 17 feet. With the exception of the interval of 1 foot between the screens, therefore, they formed a continuous screen from an altitude of 11 feet to an altitude of 24 feet. The screens were changed at each examination so that the direction in which they faced was alternated between north-south and east-west. By far the greatest number of beetles were taken at the lowest altitude (table 5), although some were taken at an altitude of 22 to 24 feet. The data do not indicate any significant effect of the direction that the screens faced upon the number of beetles captured.

SUMMARY.—The migration habits of the tobacco flea beetle were studied by means of adhesive screens. It was found that upon emergence from hibernation the beetles migrate to the first available host plants. At the time of the transplanting of tobacco, the insects tend to migrate from other host plants to newly set tobacco plants. The largest number of beetles were captured on adhesive screens at a height of 2 to 4 feet above the ground, although some were caught at an altitude of 22–24 feet. It was demonstrated that the most extensive migration takes place after the tobacco has been harvested.—1-6-40.

Table 5.—Tobacco flea beetles captured on elevated screens.

Date	Number of Beetles on Screens									
	Side Facing—				Height in Feet (Approx.)					
	N.	S.	E.	W.	11–13	13–15	15–17	18–20	20–22	22–24
Sept.										
9			33	16	17	13	5	5	7	2
13	37	29			24	16	9	7	6	4
16			8	21	8	6	2	10	3	0
19	41	42			23	19	8	18	12	3
21			35	24	20	15	10	8	5	1
23	8	8			1	6	4	3	2	0
26			6	1	2	1	0	2	1	1
29	8	4			4	1	0	1	6	0
Oct.										
3			3	1	0	3	0	0	1	0
Total	94	83	85	63	99	80	38	54	43	11

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Breeding Hosts of the Tobacco Flea Beetle

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The tobacco flea beetle (*Epitrix parvula* F.) long has been recognized as a pest of major importance on topacco being grown for flue curing. The damage can be ascribed to three stages in the growth of the plant, namely, to tobacco seedlings in the plant bed, to newly transplanted tobacco, and to tobacco growing in the field.

While flea beetle damage to tobacco seedlings in the plant bed and to tobacco growing in the field is of great importance observations by Schoene (1938), Shands *et al.* (1938), and others strongly indicate that the damage to the newly transplanted tobacco has been under-emphasized. Unpublished results of studies conducted at the Oxford, N. C., laboratory since 1935 have shown that each year newly transplanted tobacco has been populated by the beetle during two distinct periods, immediately after it was transplanted and again about 2 or 3 weeks later. The latter movement of the beetles to tobacco in the field has always occurred before a generation of the beetle could have matured on the newly set tobacco.

Studies conducted in 1938 showed that horse nettle (*Solanum carolinense* L.), the only wild host plant abundantly occurring in or near tobacco fields in the vicinity of Oxford, was of little importance as a breeding host of the beetle, and they strongly indicated that the second population increase was the result of a distinct influx of beetles. Other tests carried on in 1938 showed that tobacco in plant beds, potatoes, nightshade (*S. nigrum* L.), and tomatoes were breeding hosts of the beetle.

Further studies were conducted in 1939 to determine the importance of tobacco in plant beds and of potatoes as breeding hosts of the beetle. Nightshade and tomatoes were omitted because the former plant is of limited distribution and occurs principally in plant beds and because tomatoes are transplanted to the field so late they could be of no importance as an early-season breeding host of the beetle.

EXPERIMENTAL PROCEDURE.—Cages were placed over tobacco in plant beds located in a small woods and over potatoes in the field, and all beetles emerging in the cages were collected daily.

The tobacco plant beds were seeded on February 20. When the seedlings reached the four-leaf stage, which was between April 5 and 13, cages were placed over the plants in 20 small areas. One series of 10 areas was infested with 10 beetles per cage and the other with 20 beetles per cage.** Ten additional areas that had been naturally infested were caged on May 16 when observations showed that the first generation of beetles would soon begin emerging in plant beds. On this date the plants in all cages were thoroughly treated with a dust mixture containing one per cent of rotenone to kill all beetles present. Beginning three days after treatment and continuing for a period of approximately three months newly emerged beetles were removed from the cages daily.

The cages consisted of a wooden frame covered with cloth having 28 by 32 strands per square inch. They were cylindrical in shape, 18 inches tall, and covered an area of about one square foot.

Two wooden frame cages four feet tall and covered with the same kind of cloth were placed over plant-bed areas of 32 square feet each soon after the beds were seeded on February 20. On April 5 and 6, when the tobacco seedlings began to reach the four-leaf stage, the cages were populated with four and eight beetles per square foot. Subsequent treatment and observation of these cages were similar to those described for the small cages.

At intervals of approximately a month during the summer 10 small cages were placed over undisturbed tobacco plants remaining in the plant beds which had been naturally infested by the beetle. As soon as the cages were established the plants in each were treated with a dust mixture containing one per cent of rotenone to kill all beetles. Daily records were then kept of the numbers of newly emerged beetles recovered in each cage.

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† In cooperation with the North Carolina Department of Agriculture.

** No satisfactory method of determining the sex of living beetles was known by the author.

Table 1.—Recovery of tobacco flea beetles in tobacco plant beds following various initial infestations. Oxford, N. C., 1939.

Series No.	Date Plants Were Caged	Area per Cage, Sq. Ft.	Initial Infestation: Beetles per Sq. Ft.	Number of Beetles Recovered		
				Month	Total	Average per Sq. Ft.
1	Apr. 10	1	10	May	93	9.3
				June	1,560	156.0
				July	1,474	147.4
				Aug.	89	8.9
				Sept.	—	—
2	Apr. 13	1	20	May	103	10.3
				June	1,859	185.9
				July	928	92.8
				Aug.	30	3.0
				Sept.	—	—
3	May 16	1	Natural	May	198	19.8
				June	2,310	231.0
				July	729	72.9
				Aug.	58	5.8
				Sept.	—	—
4	June 27	1½	Natural	May	—	—
				June	—	—
				July	3,007	200.5
				Aug.	127	8.5
				Sept.	—	—
5	July 24	1½	Natural	May	—	—
				June	—	—
				July	457	30.5
				Aug.	535	35.7
				Sept.	3	.2
6	Aug. 21	1½	Natural	May	—	—
				June	—	—
				July	—	—
				Aug.	41	2.7
				Sept.	97	6.5
7	Apr. 5	32	4	May	406	12.7
				June	3,364	105.1
				July	4,244	132.6
				Aug.	1,199	37.5
				Sept.	204	6.4
	Apr. 6	32	8	May	730	22.8
				June	4,464	139.5
				July	3,866	120.8
				Aug.	1,033	32.3
				Sept.	166	5.2

Potato plantings were made on February 25 and, as the shoots appeared, cages were placed over individual plants. A series of 10 plants were infested with 10 beetles per cage and another series of 10 plants with 20 beetles per cage, on April 8 and 12. On May 16 cages were placed over individual potato plants that had been naturally infested. Beginning on May 16 and continuing until July, when all the plants had matured and died, treatment of these cages was identical with that described for the small cages used during the early part of the season in tobacco plant beds. The cages used were similar to those employed in the plant-bed studies.

RESULTS.—The results of experiments with tobacco in plant beds, as given in tables 1 and 2, show that large numbers of beetles emerged. The first beetle emergence was observed on May 25, which was during the latter part of the 3-week transplanting season. There was practically no difference in the time of first emergence between artificially infested areas and those naturally infested. The period of greatest emergence for all cages was during June and July. There appeared to be a positive but not proportional relationship between the intensity of initial infestation and the number of beetles recovered in May and June. During these months far greater numbers of beetles were recovered from areas naturally infested (series 3) than from areas artificially infested (series 1 and 2), which had higher initial infestations. The naturally infested plant bed in series 3 showed average initial infestations of 1.6, 8.6, and 6.8 beetles per square foot on April 5, May 5, and May 10, when the insects were removed with an electrically operated sucker.

The results of experiments with potatoes, as given in table 2, show that large numbers of beetles were recovered late in May and in June. First beetle emergence occurred on May 24 in plant areas artificially infested and in areas naturally infested. Beetles continued to emerge apparently as long as the roots of the plants were able to support the immature stages.

DISCUSSION OF RESULTS.—The fact that during the part of the season when beetle emergence was greatest in tobacco plant beds the caged plants, as well as those in surrounding beds which were not caged, showed little or no feeding by the beetles was an indication that the emerging beetles soon deserted the plant beds. The potential importance of the tobacco

Table 2.—Recovery of tobacco flea beetles in 1½-square-foot cages over potato plants following various initial infestations in the field. Oxford, N. C., 1939.

Series No.	Date Plants Were Caged	Initial Infestation, Beetles per Cage	Number of Beetles Recovered		
			Month	Total	Average per Sq. Ft.
1	Apr. 8	10	May	59	3.9
			June	876	58.4
			July	77	5.1
2	Apr. 12	20	May	95	6.3
			June	1,612	107.5
			July	83	5.5
3	May 16	Natural	May	405	27.0
			June	977	64.5
			July	—	—

plant bed as a breeding ground of the beetle can readily be discerned when it is realized that an average of approximately 100 square yards of plant bed are grown for each acre of tobacco transplanted to the field. It is also estimated that usually about one-tenth of an acre per farm is planted to early potatoes. The results of this study strongly suggest the desirability of controlling the beetle in tobacco plant beds, particularly during the early part of the season.

SUMMARY.—Studies were conducted at Oxford, N. C., in 1939 to determine the importance of tobacco in plant beds and of potatoes in the field as breeding hosts of the tobacco flea beetle (*Epitrix parvula* F.). Counts were made of beetle emergence in cages placed over plants that had been artificially infested with various numbers of beetles and plants that had been naturally infested. It was found that both tobacco and potatoes were breeding hosts of great importance, particularly during the early part of the season. The first generation of beetles began to emerge soon after tobacco was transplanted to the field. The evidence obtained showed that the beetles soon moved from the plant beds because the numbers that emerged in the beds were sufficiently large to have caused severe foliage injury to the plants had the beetles not moved.—1-6-40.

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Control of the Squash Bug by Calcium Cyanide*

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There is a great diversity among the recommendations for squash bug† control which suggests that none is entirely satisfactory. A number of contact insecticides appear to be effective in killing the bugs actually hit. These have included nicotine, soap and various pyrethrum preparations. In my experience, these insecticides have been only partially effective because of the impossibility of hitting a large enough percentage of the bugs by ordinary spraying operations. Truck growers find this even more difficult than do those engaged in experimental spraying. Furthermore, the effectiveness of contact insecticides may be limited by the environmental conditions. As for instance, soap is effective only when evaporation is low, which probably accounts for the varying degree of success resulting from its use.

Dusting with calcium cyanide has also been tried occasionally for control of the squash bug. The possible usefulness of the cyanide for this purpose was first mentioned by Sullivan (1924). Since then it has received attention from Little (1927), Pack (1930), Knowlton (1933), Hutson (1935), Hixon (1935), and Moore (1936). Most of these investigators used it as a dust. As a rule it caused injury to plants, and possibly because of this usually it was given little further attention.

Calcium cyanide dust applied in the open, with a bellows duster, was used by the writer for the control of squash bug in 1927 and 1928. The results were similar to those described by some of the other investigators; that is, the bugs hit were killed but plants were usually injured except during periods of very dry weather. Actual contact with the bugs was necessary, so that calcium cyanide had no marked advantage over any other contact insecticide.

Calcium cyanide dust under canvas was given a limited trial in August 1938. The hills were covered with canvas individually, and under these conditions 100 per cent of the bugs were killed during an exposure as brief as three minutes. The application differed from those previously referred to in that the dose of dust for each hill was placed under the vines, and that there was no necessity for contact with the insects. No injury to plants oc-

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† *Anasa tristis* DeG.; order Hemiptera, family Coreidae.

curred. Since no rain fell during the period when applications were made injury was not expected. The plants used were small, late-planted bush squashes.

Flake cyanide was given an experimental trial in 1939. The advantages of flake cyanide over dust are that it does not adhere to the foliage and, if dropped upon leaves, the flakes usually slide to the ground. This removed the necessity of carefully placing the insecticide under the plants to avoid foliage injury. The flakes also liberate gas more slowly than dust, which makes the former somewhat less disagreeable to handle. On the other hand, the slower action may also be rated as a disadvantage. The flakes are the cheaper of the two forms.

A field of large bush squashes was used for experiments. The size of the plants at the time the cyanide applications were made is indicated by the fact that the fruit was being harvested, and that the runners met in the row. The hills were three feet apart, and the rows 4 feet apart, making an average area of 12 square feet to be fumigated for each hill. The applications were made during midsummer between June 27 and August 2. A canvas 9 feet 6 inches wide, which was ample for covering two rows at a time, was used as a trailer. The trailer was dragged over the vines as the insecticide was applied and then was left stationary for the various periods of exposure under trial. In some of the tests about a half pint of water was poured on each dose of cyanide to hasten action.

The most satisfactory dosage for plants of this size appeared to be one ounce to the hill, divided into two parts and dropped on either side of the plants. If water was used with the cyanide, practically all bugs were killed in five minutes. If water was not used, an exposure of 10 minutes was necessary to secure satisfactory results.

The average percentage of squash bugs killed was 98.3 in small plots on which one ounce of flake cyanide with water was used for each hill. This figure is based on the results of applications on five different dates. When the same dosage and exposure was used on a large section, 91.1 per cent of the bugs were killed. The bugs which escaped were usually found hanging on the canvas.

Exposures of 3 and 4 minutes were tried but in both instances the percentage of bugs apparently killed was less than 80, and some of these were only stupified. The short exposures which were effective in 1938 when only hills were treated were not satisfactory when entire rows were involved. When a half ounce of cyanide was used at a 10 minute exposure, 56 per cent of the bugs were killed. The percentage of mortality at shorter exposures was still less satisfactory.

The practical utility of cyanide in the control of the squash bug was not given adequate trial. The high cost may prevent its use. Since cyanide has no apparent effect on squash bug eggs, a second application after the eggs have hatched will be necessary in heavily infested fields. It cannot be expected that a part of the cost can be charged to the incidental control of other pests. For example, the dosage and time of exposure which were successful against the squash bug could not be depended upon to control the striped cucumber beetle.

In the control of the squash bug, fumigation under canvas has an advantage over the use of contact insecticides in that it is not necessary to hit the bugs and consequently a much more satisfactory kill can be secured. The nearly complete kill of the bugs reduces the required number of applications. When contact insecticides are used, successive applications are necessary, sometimes because of migrations, but often because of a failure to hit a large enough percentage of the bugs. Regardless of the insecticide used, small plots are rapidly reinfested. On the other hand, an entire field was treated with cyanide in the summer of 1939 after the migration from hibernation had ceased, and the problem of successive invasions of bugs was not encountered.

The dosage required will doubtless vary depending upon the size of the plants, and the temperature and moisture at the time the application is made. Probably a dosage of one ounce to a hill will be the maximum required.

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Pea Aphid Control in Maryland During 1939[1]

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Studies on pea aphid control on Alaska peas in Maryland consisted of a replicate plot experiment and a set of control demonstration plots, both located on the Eastern Shore at Ridgely.

Replicate Plot Experiments.—Replicate experiments were carried out with the following objectives in mind: first, to compare two types of spray nozzles; second, to compare two spray pressures used with each of the two types of nozzles; third, to determine the effect of particle size on the toxicity of cubé; fourth, to compare further the effectiveness of derris and cubé; fifth, to compare the effectiveness of derris dusts and derris sprays; and sixth, to determine the effect of humidity and temperature on the toxicity of derris dusts.

METHODS.—Forty plots of peas of one-fortieth acre each were available. On these, nine treatments were made, each replicated four times, leaving four untreated check or control plots. The random block method was used in locating treatments. All treatments were made May 18, when the first blossoms were appearing. The aphid population was increasing rapidly at this time but no injury was yet apparent on the peas. All plots were harvested June 6.

Population records were made May 17, 23 and 29. Records on mosaic infection were taken June 5. Humidity, temperature, and rainfall records were kept during the entire period of the experiment.

The following treatments were applied: (1) *Black Arrow* "*88*"[2] consisting of derris 8 pounds and sodium lauryl sulfate 1 pound), used at the rate of 4 pounds per 100 gallons of water, applied with an *Agicide* boom, nozzles 6 inches apart, at 600 pounds pressure, No. 1 disks were used in nozzles. (2) Treatment same as No. 1 except 300 pounds pressure used instead of 600. (3) Same materials as No. 1 applied at 600 pounds pressure with *Hardie* nozzles which were arranged in pairs with a nozzle on each side of the boom on an extension so as to be about 15 inches apart. The nozzles were turned inward, downward and slightly to one side so as to twist the plants by the force of the spray. Ten nozzles were used on a 10-foot boom. No. 2 disks were used in the nozzles. (4) Treatment same as No. 3 except 300 pounds pressure was used. (5) *Black Arrow* "*77*"[2] (consisting of cubé 8 pounds and sodium lauryl sulfate 1 pound), 4 pounds per 100 gallons of water, *Agicide* boom, 600 pounds spray pressure. (6) Micronized[2] cubé 8 pounds and sodium lauryl sulfate $\frac{1}{4}$ pound to 100 gallons of water, *Agicide* boom, 600 pounds spray pressure. (7) *Black Arrow* "*444*"[2] (consisting of derris, talc, 5 per cent sulphur, 1 per cent sodium lauryl sulfate), applied as a dust at 10:30 A.M., actual temperature at time of application 73 to 76 degrees F., humidity 40 per cent, wind velocity 1 to 2 miles per hour, no moisture on plants. (8) Same material as in treatment 7, applied at 5 A.M., actual temperature 52 to 53 degrees, humidity 78 to 79 per cent, wind velocity 1 to 2 miles per hour. Very slight dew on plants. (9) Dust furnished by Madison Laboratory of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine,[2] containing derris and talc, 1 per cent *Averol* and 2 per cent peanut oil, applied 5 A.M., actual temperature 52 to 53 degrees,

[1] Contribution number 504, University of Maryland Agricultural Experiment Station, Department of Entomology.

[2] *Black Arrow* "*88*" contained 4.6 per cent rotenone, *Black Arrow* "*77*" contained 3.7 per cent rotenone, micronized cubé contained 1.93 per cent rotenone, *Black Arrow* "*444*" contained 1.05 per cent rotenone. Dust furnished by the Madison Laboratory contained 0.86 per cent rotenone.

humidity 78 to 79 per cent, wind velocity 1 to 2 miles per hour. Very slight dew on plants.

An attempt was made to apply 150 gallons of spray per acre on all sprayed plots. With variations in spray pressures and types of nozzles, it was found difficult to deliver the exact amount. The nozzles were calibrated at the pressures used and the rate of speed for each application and time in seconds for treating each plot calculated. A careful check was made with a stop watch and rates of application, calculated and actual, are given in table 1.

Table 1.—Rates of application of spray treatments and speed of truck calculated on basis of 150 gallons of spray per acre.

Treatment	Calculated M.P.H.	Plot Number	Actual Rate, Gals. Per Acre
1 *Agicide* nozzles	2.3	6	153 gals.
600 pounds pressure		15	143 gals.
Black Arrow "88"		21	139 gals.
		40	153 gals.
2 *Agicide* nozzles	1.6	4	155 gals.
300 pounds pressure		12	156 gals.
Black Arrow "88"		28	155 gals.
		38	149 gals.
3 *Hardie* nozzles	2.6	8	159 gals.
600 pounds pressure		17	170 gals.
Black Arrow "88"		24	145 gals.
		34	141 gals.
4 *Hardie* nozzles	1.7	10	155 gals.
300 pounds pressure		18	141 gals.
Black Arrow "88"		29	134 gals.
		31	137 gals.
5 *Black Arrow* "77"	2.3	3	167 gals.
(regular cubé)		16	148 gals.
		25	143 gals.
		35	150 gals.
6 Micronized cubé	2.3	1	139 gals.
		14	150 gals.
		30	150 gals.
		32	150 gals.

The rate of dust applications could not be accurately determined because of dust lost between plots. It was intended that all dusts be applied at 40 pounds per acre but actually about twice this amount was applied as indicated by the difference in weight of dust in the machine before and after treatments. The machine traveled approximately 3 miles per hour and a 25-foot apron was used.

Weather Conditions.—Excessive early spring precipitation delayed planting of peas generally. After planting there was ample rain until the middle of May, but from May 13 (5 days before treatment) until peas were harvested no rain fell. The result was failure of the pea crop in many sections of the state. This dry period was responsible for the slight difference in yields of experimental plots. After the first pods formed, vines became badly dried and no further growth took place. Many plants were completely killed before harvest.

With a combination of dry vines and hot weather, aphids were driven from the plants. Large numbers could be found on the ground during the hot days of late May and early June. On some commercial plantings where vines were short and thin, aphid populations were apparently entirely killed by the heat of the sun on the rapidly browning vines.

Following the application of treatments on the experimental plots, maximum daily temperatures usually reached 80 degrees or higher, while minimum temperatures varied between 50 to 80 degrees. Humidity regularly increased during the night, usually reaching 80 per cent or higher at about 4 A.M.; then it fell gradually during the day, reaching a low of 40 per cent during the afternoon. An examination of weather records shows that there was no time during the night (8 P.M. to 6 A.M.) that a temperature as high as 70 degrees occurred until May 27. Humidity varied inversely with temperature, the highest combination of the two occurring in the evening and in the morning.

Yield Results.—Because of adverse weather conditions already discussed, yields of plots indicate little as to the value of control measures. Only one pod

Table 2.—A comparison of tip counts and number of aphids per sweep, May 17, on plots 1 to 10.

Plot No.—	1	2	3	4	5	6	7	8	9	10
Aphids per tip	3.6	0.9	3.5	1.2	1.6	1.2	2.8	3.1	1.3	0.9
Aphids per sweep	27.3	28.0	27.9	22.8	25.0	21.9	20.6	22.5	18.2	16.8

per vine developed before drought affected the growth. Had there been ample precipitation undoubtedly there was sufficient aphid population to have given significant differences between some treatments. Such variations in yields as obtained were probably caused more by soil moisture conditions than any other single factor. Average yields of the various treatments varied from 1210 to 1375 pounds of shelled peas per acre while the average of untreated plots was 1070 pounds.

SIZES AND GRADES OF PEAS.—At the time of cutting, No. 3 sieve peas preponderated, with a relatively large percentage of No. 2, some No. 4 and a few No. 5 sieve. Peas from four plots (2, 6, 39, 40) were sized and canned, and the canned product graded. Sieve sizes 1, 2, and 3 graded standard as to maturity while No. 4 graded substandard.

POPULATION RECORDS.—Tip counts were made on all plots in block one. The averages ranged from 0.9 to 3.6 aphids per tip on May 17. Twenty-five tips constituted a sample on each plot. The widespread variation in these data indicates that the average aphids per sweep for ten sweeps gives a better estimate of aphid population than tip counts when averages are based on 25 tips (table 2). An average based on a large number of tips would, of course, give a more valid estimate but would require much more time than making sweep records. Tip count records on May 23 and 29 are therefore discarded.

Sweep records were made May 17, May 23, five days after treatment, and May 29, eleven days after treatment (table 3). Aphids swept on May 17 were counted in the field, those on May 23 and 29 were preserved in alcohol, taken into the laboratory and counted. All of these aphids were counted except those from the check plots, which were placed in a liter of water and the total number estimated from four aliquots taken while the suspension of aphids was agitated.

The results of population estimates following treatments show considerable variation in the value of the different treatments.

MOSAIC INFECTION.—Records were taken June 5. Only 6 to 20 per cent of plants showed characteristic symptoms in check plots while in treated plots examined, 6 per cent or less of plants showed symptoms. This was considerably less than experienced last year and was probably the result of the later appearance of aphids in 1939. The build-up of

Table 3.—Aphid populations measured by the sweep method based on averages of ten sweeps per plot.

TREATMENT	PLOT NUMBER	APHIDS PER SWEEP		
		May 17	May 23	May 29
1	6	21.9	45.5	68.8
	15	22.4	52.8	73.8
	21	43.6	121.9	155.9
	40	22.4	44.5	139.4
	Average	27.5	66.1	109.4
2	4	22.8	58.1	130.9
	12	18.4	53.0	108.5
	28	29.0	119.1	231.5
	38	30.5	84.5	134.7
	Average	25.2	78.7	151.4
3	8	22.5	29.3	56.5
	17	28.7	40.6	102.1
	24	38.3	80.9	246.2
	34	31.2	40.7	194.6
	Average	30.2	47.9	149.8
4	10	16.8	56.5	119.1
	18	29.5	72.2	141.9
	29	24.1	93.9	282.6
	31	26.7	95.6	355.5
	Average	24.3	79.5	224.7
5	3	27.9	124.0	217.9
	16	21.0	110.1	266.9
	25	34.0	191.6	322.8
	35	27.5	150.9	262.9
	Average	27.6	144.2	268.8
6	1	27.3	46.9	172.3
	14	23.0	68.9	133.9
	30	26.0	47.8	254.5
	32	24.1	67.2	185.0
	Average	27.6	57.6	186.4
7	7	20.6	84.4	112.1
	19	23.5	22.6	47.9
	27	25.3	113.6	223.2
	36	24.2	34.4	40.4
	Average	23.4	63.7	105.9
8	5	25.0	38.2	39.5
	13	15.0	16.0	28.5
	23	35.0	42.6	87.1
	33	24.3	21.5	58.6
	Average	24.8	29.6	53.4
9	9	18.2	32.1	93.5
	20	27.1	20.5	62.1
	22	42.9	72.7	141.4
	37	28.2	18.5	45.8
	Average	29.1	35.9	85.7
10	2	28.0	502.0	1461.0
	11	21.5	670.0	1481.0
	26	24.6	1077.0	2794.0
	39	24.8	1265.0	1632.0
	Average	24.7	878.6	1842.0

Table 4.—"t" Test of differences between several treatments based on population records of May 23 (table 3) five days after treatments.[3]

TREATMENTS COMPARED	TREATMENT NUMBERS	t-VALUE	BETTER KILL
Black Arrow "77" and Micronized cubé	5 and 6	4.064	Micronized cubé
Black Arrow "88" and *Black Arrow* "77"	1 and 5	7.497	*Black Arrow* "88"
Hardie nozzles, 600 pounds pressure and *Hardie* nozzles, 300 pounds pressure	3 and 4	3.640	600 pounds pressure
Black Arrow "88" and *Black Arrow* "444," 5 A.M.	1 and 8	2.440	*Black Arrow* "444"
Hardie nozzles, 600 pounds pressure and *Agicide* nozzles, 600 pounds pressure	1 and 3	2.290	*Hardie* nozzles
Black Arrow "444", 5 A.M., and *Black Arrow* "444," 10:30 A.M.	7 and 8	2.325	5 A.M. application
Peanut oil dust and *Black Arrow* "444," 5 A.M.	8 and 9	0.745	*Black Arrow* "444"
Agicide nozzles, 600 pounds pressure and *Agicide* nozzles, 300 pounds pressure	1 and 2	1.282	600 pounds pressure

[3] From Fisher's table of t when n=3 at the 5 per cent point (odds 19–1) t=3.182; at the 10 per cent point (odds 9–1) t=2.333 at the 20 per cent point (odds 4–1) t=1.638.

Table 5.—"t" Test of differences between several treatments based on population records of May 29 (table 3) eleven days after treatment.[3]

TREATMENTS COMPARED	TREATMENT NUMBERS	t-VALUE	BETTER KILL
Black Arrow "77" and Micronized cubé	5 and 6	4.379	Micronized cubé
Black Arrow "88" and *Black Arrow* "77"	1 and 5	10.787	*Black Arrow* "88"
Hardie nozzles, 600 pounds pressure and *Hardie* nozzles, 300 pounds pressure	3 and 4	2.562	600 pounds pressure
Black Arrow "88" and *Black Arrow* "444" 5 A.M.	1 and 8	4.848	*Black Arrow* "444"
Hardie nozzles, 600 pounds pressure and *Agicide* nozzles, 600 pounds pressure	1 and 3	1.864	*Hardie* nozzles
Black Arrow "444," 5 A.M., and *Black Arrow* "444," 10:30 A.M.	7 and 8	1.565	5 A.M. application
Peanut oil dust and *Black Arrow* "444," 5 A.M.	8 and 9	2.045	*Black Arrow* "444"
Agicide nozzles, 600 pounds pressure and *Agicide* nozzles, 300 pounds pressure	1 and 2	2.367	600 pounds pressure

Table 6.—Treatments applied in demonstration plots.

PLOT NUMBER	TREATMENT	AMOUNT PER ACRE	TIME OF TREATMENT
1	Spray, derris 4 per cent,[4] rotenone 3 pounds plus ¼ pound sodium lauryl sulfate per 100 gallons, 300 pounds pressure, commercial machine	125 gals.	May 18, 11 A.M.
2	Spray, same material as plot 1 applied with *Agicide* boom, 600 pounds pressure	125 gals.	May 18, 1:30 P.M.
3	Spray, *Black Arrow* "88," 4.6 per cent rotenone, 4 pounds per 100 gallons. Applied with commercial machine as in plot 1	125 gals.	May 18, 11:30 A.M.
4	Spray, same materials as plot 3 applied with *Agicide* boom at 600 pounds pressure	125 gals.	May 18, 2 P.M.
5	*Black Arrow* "444," dust, 1.05 per cent rotenone	60 lbs.	May 17, 9:30 A.M.
6	*Black Arrow* "444," 1.05 per cent rotenone, dust	60 lbs.	May 17, 7:30 P.M.
7	*Agicide* dust, 0.44 per cent rotenone, formula DI-12	65 lbs.	May 17, 10 A.M.
8	Micronized cubé dust, 1.34 per cent rotenone	55 lbs.	May 17, 10:30 A.M.
9	Peanut oil dust 2 per cent, 0.86 per cent rotenone, 1 per cent *Arerol* plus talc	50 lbs.	May 17, 10:45 A.M.
10	Spray, rotenone concentrate (extract of cubé) 3 pints per 100 gallons, applied with *Agicide* boom, 600 pounds pressure	125 gals.	May 18, 2:15 P.M.
11	Spray, micronized cubé, 1.93 per cent rotenone, 7 pounds plus ¼ pound sodium lauryl sulfate per 100 gallons, applied with *Agicide* boom, 600 pounds pressure	125 gals.	May 18, 2:30 P.M.
12	*Black Arrow* "666," dust (cube), 1 per cent[4] rotenone	55 lbs.	May 17, 11:30 A.M.

[4] Commercial analysis, actual rotenone analysis not determined for these two materials.

aphid population in 1939 was two weeks later than in 1938.

DISCUSSION.—Population records show considerable differences in the effectiveness of some of the treatments (table 3). Though population results do not lend themselves to complete analysis of variance procedure, "t" tests for differences between some treatments were made (tables 4 and 5).

grees. There was also considerable wind in the afternoon of May 18 at the time of application of the sprays. Yield results and population records are given in table 7. Aphid population estimates were based on 10 sweeps per plot.

SUMMARY.—From observations of the results of sweep records, table 3, and from a statistical analysis of the results, derris appears to be superior to ordinary cubé

Table 7.—Population records and yield records of the demonstration plots.

PLOT NUMBER		MAY 17	MAY 23	MAY 26	MAY 29	POUNDS OF VINES PER ACRE	POUNDS OF SHELLED PEAS PER ACRE
1	Derris spray commercial machine	37	—	162	184	1576	405
2	Same material as Plot 1 with *Agicide* boom, 600 pounds pressure	34	82	141	138	1372	390
3	*Black Arrow* "88" commercial machine	43	195	165	167	872	267
4	*Black Arrow* "88," *Agicide* boom, 600 pounds pressure	35	30	37	41	969	311
5	*Black Arrow* "444" dust, day application	50	16	27	22	1631	578
6	*Black Arrow* "444" dust, night application	34	13	48	30	2034	657
7	*Agicide* dust	42	69	81	76	1711	589
8	Micronized cubé dust	44	30	35	23	2713	931
9	Peanut oil dust	43	11	23	24	1792	544
10	Rotenone concentrate spray	44	29	33	48	1872	628
11	Micronized cubé spray 3 pounds per 100 gallons	42	38	31	37	2422	792
12	*Black Arrow* "666" (cubé dust)	29	13	18	18	2341	705

CONTROL DEMONSTRATION PLOTS.—Twelve plots, 899 feet by 30 feet (plots 1 and 3 treated with a commercial machine, 899 feet by 25 feet), were marked out in a field adjacent to the experimental plots already discussed. The materials used, the amount applied per acre, time of application, etc., are given in table 6. Sweep records and yield records, both of vines and shelled peas, were taken (table 7).

At the time of applying dusts in the morning of May 17, the wind was blowing 5 to 10 miles per hour, the sun was bright, and the plants were dry. The temperature was 75 ± 5 degrees. At the time of the evening application there was a light dew, the wind approached 10 miles per hour, and the temperature was 65 degrees. There was also considerable wind in the afternoon of May 18 at the time of application of the sprays. Yield results and population records are given in table 7. Aphid population estimates were based on 10 sweeps per plot.

SUMMARY.—From observations of the results of sweep records, table 3, and from a statistical analysis of the results, derris appears to be superior to ordinary cubé in effectiveness against the pea aphid. Good kill obtained with micronized cubé indicates that fine grinding may increase the toxicity. Dusts appear to be slightly better than sprays under the conditions of application on these plots. Dusts applied at high humidity when dew was on the plants gave slightly better results than dusts applied later in the day when temperature was higher, humidity lower, and plants dry.

At 300 pounds pressure, *Agicide* nozzles give a better coverage than the ordinary type of spray nozzles. At 600 pounds pressure, the ordinary nozzles gave as good results as the *Agicide* nozzles even though only one-half as many of the ordinary nozzles were used on a boom of the same length.—1-6-40.

ALFALFA weevil quarantine of Georgia, Idaho, Michigan, Missouri, Nebraska, and Wisconsin have been revised in 1940 to include additional area found infested in the past year.

Rate of Reproduction of the Pea Aphid on Different Alfalfa Plants*

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In the spring of 1934 during a severe infestation of the pea aphid, *Illinoia pisi* (Kalt) on alfalfa in Kansas, Painter & Grandfield (1935) noted differences in degree of injury to plants growing in experimental plots and fields on the Agronomy farm at the Kansas Agricultural Experiment Station. Basis of selection of the plants used was either apparent resistance or apparent susceptibility to the pea aphid and the plants were either potted or transplanted to a special nursery. This paper records some results on the rate of development of the pea aphid on these plants and some of their progeny. The purpose of these experiments was to determine if susceptibility or resistance of alfalfa plants to the pea aphid, as determined by the reaction of plants under heavy infestation in the field, was associated with the rate of reproduction of the aphids when confined to these plants.

Several references to plants and varieties resistant to aphids have been made in the literature. Delong & Jones (1926) found certain plants of the Houghton variety on which the gooseberry aphid could not maintain a population. Le Pelley (1932) reported that the woolly apple aphis would not reproduce on the Northern Spy variety. Winter (1929) found that the Herbert variety of raspberry was more resistant to the raspberry aphid than was any other variety tested. More recently Huber & Schwartze (1938) showed that resistance to the raspberry aphid differed between raspberry varieties. They found that aphids reared in the greenhouse failed to reproduce and maintain a population on several varieties and that these same varieties were the most resistant under field conditions.

Searls (1932) reported that certain varieties of peas were more resistant to pea aphids than others. Blanchard & Dudley (1934) isolated alfalfa plants on which they were unable to get pea aphids to live. Painter & Grandfield (1935) gave a report of the marked variation in the injury and number of aphids on different varieties of alfalfa as well as different plants of the same variety.

Materials and Methods.—Non-moisture proof cellophane cages seven inches long and three inches in diameter perforated with holes small enough to keep the smallest nymphs from escaping were used to confine aphids on branches of alfalfa (Fig. 1). Five last instar nymphs were placed in each cage and left for 10 days at the end of which time the numbers of dead and living adults and nymphs were recorded. Where possible three cages were used on each plant. Some plants were tested in the greenhouse and kept at approximately 60 degrees and others at about 78 degrees. The temperatures for the experiments that were conducted outside averaged from 43° to 61°. All the aphids used in these experiments were the progeny of about 100 aphids collected from an alfalfa field near Manhattan, Kansas in the fall of 1934. The experiments were conducted from December, 1934 to May, 1935; 354 different alfalfa plants were tested and 5,805 parental aphids were used.

Effect of Temperature and Host on the Rate of Reproduction.—The pea aphid requires a rather cool temperature for maximum reproduction. Smith & Davis (1926) stated that there was a decided increase in the number of young pea aphids produced on alfalfa when the temperature decreased from 70 degrees to 65 degrees.

Records of rate of reproduction of aphids on several plants at different temperatures are shown in table 1. A plant designated as No. 3 was a selection from a field of Kansas common alfalfa and proved to be a very desirable host for the aphids. When aphids were confined to this plant at three different times and at three different temperatures, they reproduced faster at 61 degrees than at either 57 de-

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FIG. 1.—Non-moisture proof cellophane cages used for study of rate of reproduction of aphids on alfalfa plants.

grees or 78 degrees. The mortality of the aphids was slightly higher at 61 degrees and much higher at 78 degrees than at 57 degrees. A resistant selection from Turkestan F.C. No. 19316 proved to be very undesirable for aphid reproduction, and when aphids were confined to this plant at 78 degrees, 61 degrees and 57 degrees there was an increase of less than one aphid per parent under each of the three temperatures. The percentage of aphids dead at the end of 10 days on this resistant plant averaged above 80 per cent at all three temperatures.

Sixteen plants which appeared to be resistant in the field were tested at an average of about 61 degrees and also at about 44 degrees. The number of aphids per parent produced in 10 days at the two temperatures was approximately the same, however, 46.2 per cent of the aphids were dead when the temperature was 61 degrees, while only 1.0 per cent were dead when the plants were tested at 44 degrees. Ten other plants that had appeared to be susceptible under field conditions were also tested at temperatures approximately 61 degrees and 44 degrees. In this case an average of almost three times as many aphids per parent were produced at 61 degrees than at 44 degrees, and the aphid mortality was only 2.2 per cent at 61 de-

Table 1.—Effect of temperature and host plant on rate of reproduction of pea aphids, Manhattan Kansas, 1935.

Description of Plants Selections as Noted	Approx. Temp. °F	No. of Parent Aphids	No. of Adults at End of 10 Days		No. of Nymphs at End of 10 Days		Increase per Aphids (Dead and Living)	Percentage Aphids Dead
			Dead	Alive	Dead	Alive		
No. 3 Kansas Common	78	25	17	8	58	290	13.9	20.1
No. 3 Kansas Common	61	15	1	45	4	308	22.9	1.4
No. 3 Kansas Common	57	5	0	5	0	41	8.2	.0
No. 5 Turkestan 19316	78	30	30	0	24	2	.9	96.4
No. 5 Turkestan 19316	61	15	15	0	10	0	.7	100.0
No. 5 Turkestan 19316	57	10	9	1	0	1	.1	81.8
16 resistant plants	61	160	123	61	498	662	7.4	46.2
16 resistant plants	44	170	7	163	10	1495	8.9	1.0
10 susceptible plants	61	95	17	264	42	2368	27.3	2.2
10 susceptible plants	44	90	2	88	0	890	9.9	.1

Table 2.—Rate of reproduction of the pea aphid on resistant and susceptible alfalfa plants and their selfed progeny, Manhattan, Kansas, 1935.*

Description of Plants Tested	Number of Plants	Average Increase of Live Aphids per Parent in 10 Days	Range in Average Increase per Aphid	No. of Plants on Which the Ave. Increase per Aphid Was More Than 5	No. of Plants on Which the Ave. Increase per Aphid was More Than 10
Resistant field selections, 1934	12	1.8	0- 6.4	1	0
Selfed progeny of above plants	74	.9	0- 2.4	0	0
Susceptible field selections, 1934	3	16.7	15-18.1	3	3
Selfed progeny of above plants	18	5.0	0-18.5	5	2

* All plants tested when the average temperature was between 57 and 61 degrees Fahrenheit.

grees and 0.1 per cent at 44 degrees.

The percentage of dead aphids in these tests usually increased with the rise in temperature in the case of both resistant and susceptible plants. This increased death rate, like the increased birth rate, is probably related to higher metabolic rate at higher temperatures and suggests a deficiency in available food for aphids in the resistant plants where the increased death rate is much higher than on the susceptible plants. Among the individual plants tested there was even a wider difference in the rate of reproduction and in the death rate than that illustrated by plants 3 and 5. The final result was that aphids on resistant plants appeared to have a lower optimum temperature than did aphids on susceptible plants.

In table 2 the rate of reproduction of aphids confined to plants that were selected in the field in 1934 is compared with the selfed progeny of these plants. The average increase of pea aphid in 10 days on 12 plants that appeared to be resistant in the field was 1.8, while 74 selfed progeny of these 12 plants showed an increase of only 0.9 aphids per parent. The average increase per parental aphid on three susceptible plants was 16.7 while the average increase was only 5.0 on the 18 selfed progeny from these three plants. The average temperature during the time these experiments were conducted was between 57 degrees and 61 degrees. In both instances the increase on the progeny was less than on their parents. Since the progeny of these plants in all cases were only three or four months old, these data may indicate that the age of plant influences the rate of aphid reproduction.

Forty plants that appeared to be resistant and 12 field plants that appeared to be susceptible were tested at various temperatures. All 12 susceptible plants proved to be favorable host plants for the aphids. The range in average increase of live aphids per parent in 10 days for these plants was from 5.4 to 33.2. Eight of the 40 resistant selections appeared to furnish satisfactory food for aphid reproduction. This fact is not necessarily contrary to expectations because when the resistant selections were made in the field, some were heavily infested with aphids but not greatly injured. Thus, it would appear that some plants are resistant because the aphids cannot maintain a population on them, while other plants are resistant because they can better withstand the feeding of aphids in the same numbers which cause severe injury to susceptible plants.

In one series of experiments, aphids were caged on vegetative and flowering branches of the same plant at the same time. The result of this experiment is shown in table 3. In every test the average increase per parental aphid in 10 days was greater on the flowering branches than on the vegetative branches. Considering the average for the six plants tested, the increase per parent was 15.6 for the flowering branches and 2.1 for the vegetative branches. On some plants this difference was slight as with the F_2 hybrid of 3-2519×3-2512, where the average increase per parent was 3.8 and 1.4 for the flowering and vegetative branches respectively. The greatest difference shown in this respect was on plant 1-3521-4-8 where the increase was 26.4 per parent on the flowering branch as compared to only 1.0 on the vegetative branch. The difference in the rate of development of the aphids

Table 3.—Difference in Increase of Aphids on flowering branches and vegetative branches of the same plant, Manhattan, Kansas, 1935.

PLANT NO.	NO. OF PARENTAL	NO. OF ADULTS AT END OF 10 DAYS		NO. OF NYMPHS AT END OF 10 DAYS		AVE. INC. PER APHID IN 10 DAYS	TEMP.	TYPE OF BRANCH	DIFFERENCE IN AVE. INC. PER APHID IN 10 DAYS ON FLOWERING AND ON VEGETATIVE BRANCHES
		Dead	Alive	Dead	Alive				
5-0317 (316)	5	3	3	0	44	8.8	78	Flowering	
5-0317 (316)	5	5	0	0	0	0	78	Vegetative	8.8
1-2821-2C	5	3	2	0	19	3.8	78	Flowering	
1-2821-2C	5	5	0	13	1	.2	78	Vegetative	3.6
1-2821-2E	5	3	2	0	8	1.8	78	Flowering	
1-2821-2E	5	5	0	11	3	.6	78	Vegetative	1.2
1-3821-4-8	5	0	14	0	132	26.4	78	Flowering	
1-3821-4-8	5	3	2	4	5	1.0	78	Vegetative	25.4
1-3821-4-16	10	0	45	0	325	32.5	78	Flowering	
1-3821-4-16	5	0	5	0	46	9.2	78	Vegetative	23.3
3-2819 × 3-2812 1F2	5	2	3	2	19	3.8	78	Flowering	
3-2819 × 3-2812 1F2	5	4	1	8	7	1.4	78	Vegetative	2.4
Total for Flowering	35	11	69	2	547	15.6	78	Flowering	
Total for Vegetative	30	22	8	36	62	2.1	78	Vegetative	13.54

on the two types of branches is probably due to the difference in the chemical composition of the food available to the insect.

SUMMARY.—The optimum temperature for pea aphid reproduction and life was several degrees higher on alfalfa plants that appeared to be susceptible under field conditions than on plants that appeared to be resistant.

The pea aphid reproduced more rapidly and the mortality was less on alfalfa plants that appeared to be susceptible under field conditions than on those that appeared to be resistant.

Aphids reproduced more rapidly on selfed progeny of susceptible selections than on the selfed progeny of resistant selections, but the progenies varied considerably in this respect.

Some alfalfa plants which appeared to be resistant in the field furnished satisfactory food for aphid reproduction. These plants may be resistant because of their ability to withstand the feeding of aphids.

When aphids were confined to flowering and vegetative branches of the same plant, they reproduced much faster on the flowering branches.

Although in this summary of the experiments, plants have been classed as resistant or susceptible, there was considerable range in mortality and rate of reproduction within the two groups.—1-9-40.

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Methyl Bromide Fumigation for Control of Asiatic Beetle Grubs Attacking Azalea Plants

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The control of insects attacking the underground portions of plants has been difficult of solution, particularly when the infestation occurs during the growing of the crop. Treatments with chemicals have not proven very practical because of the danger of injuring the plants, the difficulty of applying the treatment and the cost. The recent development of methyl bromide for the fumigation of balled nursery plants and the use of dichlorethyl ether for the control of certain soil insects seemed to provide two chemicals which could be used with a considerable degree of safety in killing insects in soil containing growing plants. This paper gives the results of some tests in killing the Asiatic beetle grub, *Anomala orientalis* Waterhouse, attacking the roots and stems of azalea plants by use of methyl bromide.

NATURE OF THE INJURY TO AZALEAS.—The Asiatic beetle is abundant in certain localities in northern New Jersey and causes considerable damage to azaleas, rhododendrons and other plants grown in nurseries. The injury to azaleas consists of the grubs eating the roots, often completely destroying them, and in eating the bark on the stem immediately above the roots and extending as high as the plant is set in the soil. This injury is sometimes quite severe in raised or ground benches in the greenhouse and in beds outdoors. The large amount of humus and moisture necessary for growing the azaleas makes ideal conditions for grub infestation. In the ground benches or in beds outdoors the grubs may be found as deep as ten inches, while in the raised benches they are often found at the bottom of the soil. The injury to one and two year old plants is much more severe than to older plants. The lack of an effective and safe chemical soil treatment has caused a considerable increase in hand labor in that it is often necessary to lift the growing azalea plants and remove the grubs from the soil ball and from the soil by hand methods. Preventing injury by the Asiatic beetle grubs may be accomplished by treating the soil before the plants are set in it and by treating the soil containing the plants.

METHODS OF USING THE METHYL BROMIDE.—Methyl bromide was applied to soil containing the growing azalea plants in three ways. The first method consisted of fumigation under a galvanized tin box 4 feet by 6 feet and 2 feet high. The box was placed over the area to be treated with the lower edge pressed firmly into the soil and the soil pressed down along the outside edge of the box. The required amount of methyl bromide was injected on cotton under a hole in the center of the top of the box. The hole was then plugged with a rubber stopper.

The second method of treatment consisted of mixing one part of methyl bromide with 5 parts of either methyl alcohol or ethyl alcohol. Methyl alcohol was usually used since there appeared to be no difference between the two for the purpose and it was more easily obtained. If the temperature of the alcohol is above 70 degrees F. the methyl bromide is likely to boil out in the proportions of 1 part methyl bromide to 5 parts of alcohol. This mixture was injected into the soil at a rate sufficient to give one-half, 1 or 2 cc. of actual methyl bromide per square foot. The injections were usually made at about 12 inch intervals although some injections were made at 6 inch intervals. The injections were made with a *Larvajector* manufactured by Innis Speiden and Company, Inc. for use with their *Larvacide* and delivered at the rate of from 1 to 5 cc. of liquid for each injection. The methyl bromide and alcohol solution was usually injected into the soil at a depth of 3 to 5 inches.

The third method consisted of mixing 1 part of the methyl bromide in 5 parts of alcohol, as described in the preceding paragraph, diluting this mixture in water and sprinkling over the soil. Usually about 300 cc. of the mixture were added to 3 gallons of water and, if 1 cubic centimeter of methyl bromide per square foot was desired the 3 gallons of the liquid were sprinkled over an area of 50 square feet. There was some tendency for the mixture of methyl bromide and alcohol to boil when poured into water and if the tem-

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perature of the water was above 70 degrees F. there appeared to be considerable loss of the methyl bromide.

TESTS WITH THE FUMIGATING BOX.—Azalea plants, variety Petrick, in a ground bench in a greenhouse were fumigated April 10, 1939, under the fumigation box previously described. The soil temperature was 64 degrees F. A dose of 28 cc. of methyl bromide ($1\frac{1}{6}$ cc. per square foot) was used for $2\frac{1}{2}$ hours. When examined 6 days after fumigation all the Asiatic beetle grubs were dead or nearly dead. Grubs were killed to a depth of 10 inches. No injury occurred to the roots, stems or foliage.

In a second test made May 5 on azalea plants growing in outdoor frames 30 cc. of methyl bromide were used in the fumigating box ($1\frac{1}{4}$ cc. methyl bromide per square foot). The soil temperature was 58 degrees at 2 inches and 54 degrees at 5 inches. Time of fumigation was $2\frac{1}{2}$ hours and the variety of azaleas was Macracantha. An examination 6 days after fumigation showed 61 dead or nearly dead grubs and 10 grubs able to crawl, some of which may have been affected. The low soil temperature was probably responsible for the incomplete kill of the grubs. The plants were not injured by the fumigation.

Further tests were made September 1 on azaleas in a raised bench in a greenhouse. The variety was Charles Encke. The soil temperature was 68 to 70 degrees at the time of treatment and the dose of methyl bromide was 1 cc. per square foot with an exposure of 2 hours. All the grubs were killed and no injury was done the plants.

Another test was made September 8 in soil on raised benches where the temperature varied from 75 to 81 degrees. The dose of methyl bromide was 1 cc. per square foot and the exposure period 2 hours. The plants were 10 to 12 inches tall and the varieties were J. L. Bobbink, Rose Queen and Purity. When the soil was examined 3 days after treatment no live grubs were found. Slight leaf burn occurred on the variety J. L. Bobbink. No injury occurred to the varieties Rose Queen and Purity.

INJECTING METHYL BROMIDE AND ALCOHOL INTO THE SOIL.—The first soil injection tests were made August 7 on 10 to 12 inch azaleas (variety Petrick) growing in raised benches and in ground benches The raised benches were constructed of cement slabs about $1\frac{1}{4}$ inches thick, the joints of which fit very tightly. This tight construction of the raised benches evidently prevented the gas from penetrating downward and apparently was responsible for some of the injury caused to the plants as is discussed later. The soil in the ground benches was 10 to 11 inches deep. The soil temperature was not taken at the time of the injection. However, it was probably 80 degrees or slightly higher.

The methyl bromide-alcohol solution was injected at the rate of 3 cc. every 6 inches giving approximately 2 cc. of methyl bromide per square foot. Two treatments were made in the raised benches and one in the ground bench at the above dilution. One treatment was made in the ground bench in which 5 cc. of the methyl bromide-alcohol solution was injected every 6 inches giving approximately $3\frac{1}{2}$ cc. of methyl bromide per square foot.

All Asiatic beetle grubs in all plots were killed within 4 days after treatment. Injury to some of the plants appeared on August 15, 8 days after treatment. This was the typical browning of the roots and of the bark on the stems above the roots as high as the ground level. The injury was most severe in the raised benches where from 15 to 30 per cent of the plants were killed. The injury to the plants in the ground benches was not so severe but about 15 per cent of the plants were killed. It is presumed that the tight construction of the cement sides and bottom in the raised benches prevented the gas from escaping downward and resulted in the increased injury as compared with the ground benches.

In two other tests in which the methyl bromide and alcohol solution was injected into the soil at the rate of 5 cc. every 10 inches complete kill of the grubs was obtained but the plants were killed to the extext of 25 to 30 per cent. The soil temperatures in both treatments were from 80 to 82 degrees.

Treatments made September 1 in raised benches with a soil temperature of 68 to 70 degrees resulted in little or no injury to plants and gave complete kill of the grubs. Two plots were treated by injecting $2\frac{1}{2}$ cc. of the methyl bromide-alcohol solution every 6 inches and there were two plots

in which 6 cc. were injected every 12 inches. No injury occurred to the plants where the injections were made 6 inches apart and only 5 per cent of the plants were killed in one of the two plots where 6 cc. of the solution was injected 12 inches apart. The dead plants were close to the points where injections were made.

It is apparent that most of the azalea plants killed in the tests where the methyl bromide and alcohol solution was injected into the soil were those close to the point of injection. Where the injections were made at 6 inch intervals the injury was not so severe as where larger quantities were injected at 12 inch intervals. Also the injury was not as great with a soil temperature of 70 degrees as at 80 degrees or above.

METHYL BROMIDE-ALCOHOL SOLUTION IN WATER.—On August 17, 200 cc. of the methyl bromide and methyl alcohol solution were diluted in 3 gallons of water and applied to 30 square feet and 15 square feet respectively of beds containing growing azalea plants infested with Asiatic beetle grubs. This gave a dose of approximately 1 cc. and 2 cc. respectively, of methyl bromide per square foot. The soil temperature at the time was 80 to 82 degrees. The treatments were in raised benches with cement sides and bottom and in a ground bench. The azaleas were 10 to 12 inches tall. All the grubs were killed. Injury began to appear on the azalea plants on August 15, eight days after treatment. In the raised benches, with the cement construction, 63 per cent of the plants were killed where 1 cc. of methyl bromide was applied per square foot and 50 per cent were killed where 2 cc. of methyl bromide were used per square foot. In the floor benches, where the soil was deeper, 1.4 per cent of the plants were killed with the 1 cc. dose of methyl bromide and 5 per cent with the 2 cc. dose.

A test was made August 21 on azalea plants in a raised bench of wood construction. The soil temperature was 88 to 89 degrees. A dose of methyl bromide equal to one-quarter cc. per square foot gave 6.2 per cent dead grubs, one-half and three-quarters cc. per square foot both killed 25 per cent of the grubs, and 1 cc. per square foot killed 91 per cent of the grubs. No injury occurred to the plants in any of the treatments.

Additional tests were made in September with the methyl bromide-alcohol solution in water sprinkled over the area to be treated. Soil temperatures were 70 and 75 degrees. In one of the tests the soil contained considerable humus and was rather wet. The dose was equivalent to 1 cc. of methyl bromide per square foot. The following varieties were used in the tests: Charles Encke, Petrick Superba, Rose Queen, Purity, Fire Light, Madam Petrick, Coral Bell and Salmon Beauty.

Excellent grub control was obtained in most cases. No injury occurred to any of the treated plants except in the variety Coral Bell. This variety is quite susceptible to injury from methyl bromide fumigation. In this particular test one plant out of 12 treated showed some browning of the stem.

FUMIGATION OF FALLOW SOIL.—Three large greenhouses were used at one of the nurseries for growing azaleas during the fall, winter and spring months. In late May or early June the plants were transferred to the fields and the soil allowed to lie fallow, without watering, during June, July and August. The beds were all on the ground and the tillable soil was about 12 inches deep. This soil became quite dry and hot during the summer. There was a heavy infestation of Asiatic beetle grubs which did not seem to be seriously affected by the drying out and heating of the soil during the summer months or by the lack of any plants upon which they could feed growing in the soil.

On September 1, two plots, 12 by 18 feet, were treated with each of the following materials. (1) Methyl bromide, 2 cc. and 1 cc. per square foot, injected into the soil in the form of the methyl bromide-methyl alcohol solution. The injections were about 10 inches apart and 4 to 5 inches deep. (2) Chloropicrin, 3 cc. and 2 cc. per square foot, injected about 5 inches deep and 11 to 12 inches apart. (3) Carbon bisulfide, $1\frac{1}{4}$ and three quarters ounce per square foot. This was applied in shallow furrows about 3 inches deep and 12 inches apart. The soil was raked over the carbon bisulfide immediately after it was applied in the furrows.

Before making the treatments the soil had been cultivated twice with a rototiller while dry. After cultivation it was watered thoroughly and the treatments were not made until two days after water-

ing. The soil was loose, moist but not wet except in several small spots.

The treatment was made September 1. Twenty-five square feet in each treated plot were examined September 6 for live grubs. No attempt was made to determine the number of dead grubs since these had turned black and were decaying. Nine live grubs were found in an area of about 4 square feet in the methyl bromide plot treated with 2 cc. per square foot. No live grubs found in the remaining 21 square feet of this plot or in the plot treated with 1 cc. of methyl bromide per square foot. No odor from the methyl bromide remained. Thirty live grubs were found in the chloropicrin plot treated with 3 cc. per square foot and 7 live grubs in the plot treated with 2 cc. per square foot. These grubs were all within 2 to 3 inches of the surface where there was no chloropicrin odor. The odor was strong below about the 4 inch depth. Apparently the chloropicrin had been injected too deeply in the soil and the fumes had not had time to come to the surface. No live grubs were found in either of the plots treated with carbon bisulfide and the odor was very strong. Thirty-five live grubs were found in the check plot at depths ranging from 2 to 6 inches.

It would appear from observations made at the time of examining the plots that the methyl bromide and chloropicrin would have given as complete kill had they been injected nearer the surface. It was also apparent that the soil treated with chloropicrin and carbon bisulfide could not be planted to azaleas for two to three weeks after treatment. Azalea plants of three varieties were set out in the two plots treated with methyl bromide to determine whether aeration of the soil was necessary. These plants were examined from time to time for about three weeks. No injury occurred to the plants and the roots showed continued growth.

The remainder of the soil benches in the three houses, an area about 150 feet wide by 300 feet long, was treated with the methyl bromide-methyl alcohol solution on September 8, 11, 12, and 13. Five cc. of the solution were injected every 10 to 11 inches about 4 inches deep. On September 15, 24 diggings, 4 feet square were made. Many dead grubs were found but no live ones. The first plants were brought into the house on September 18 and set into the soil. No injury occurred to the plants from setting them into the treated soil, neither has any grub injury occurred.

SUMMARY AND CONCLUSIONS.—Three methods of applying the methyl bromide were developed. These are: (1) fumigation under a box which confines the charge of methyl bromide to a definite area; (2) the dilution of methyl bromide, 1 part in 5 parts of either methyl alcohol or ethyl alcohol, and injecting this mixture into the soil at rates equivalent to 1 and 2 cc. of methyl bromide per square foot; and (3) the use of methyl bromide, 1 part in 5 parts of either methyl alcohol or ethyl alcohol and diluting this mixture in water and sprinkling it over the soil to be treated for the grubs.

Fumigation of soil and azalea plants in raised benches and in floor benches by confining the methyl bromide under a fumigating box, at the rate of 1 cc. per square foot of area treated, caused no injury to the plants in the spring tests and only slight leaf burn to the variety L. J. Bobbink in the fall tests. The soil temperatures varied from 54 degrees in some of the spring tests to as high as 81 degrees in some of the fall tests. A complete kill of the Asiatic beetle grubs was obtained in all tests except those conducted in the spring when the soil temperature was 54 degrees at 8 inches and 58 degrees at 4 inches. This method of fumigating the soil infested with grubs and containing growing azalea plants would seem to be safe and effective but is rather difficult of practical application.

Fumigation of soil infested with Asiatic beetle grubs and containing growing azalea plants by injecting into the soil a mixture consisting of 1 part of methyl bromide and 5 parts of either methyl alcohol or ethyl alcohol, at a rate adjusted to give 1 cc. and 2 cc. of methyl bromide per square foot, killed most of the grubs but under most conditions caused some injury to the plants. Injury was quite likely to occur at soil temperatures approaching 80 degrees or above. The injured plants were usually those closest to the points where the mixtures were injected into the soil. When the injections were made at 6 inch intervals, rather than 10 to 12 inch, giving one-half cc. of methyl bromide per injection, no injury, or only slight injury, occurred. It is believed that this method of applying the

methyl bromide to soil containing growing plants will always be accompanied by some plant damage because of the initial heavy concentration of the gas at the point of injection.

Fumigation of soil infested with Asiatic beetle grubs, and containing growing azalea plants, by diluting the mixture of methyl bromide and alcohol in water and sprinkling this mixture over the area to be treated, under most conditions, produced a satisfactory kill of the grubs without causing injury to the plants. Applications of methyl bromide in this manner, equal to one-quarter cc. per square foot, resulted in very little kill. One-half and three-quarters cc. per square foot gave less than 50 per cent kill while 1 cc. per square foot usually gave almost complete or complete kill of the grubs. There were some indications that where the soil contained considerable humus and was wet at the time of sprinkling the mixture over the surface, there was some danger of injuring the root and stems of the plants. It is believed that with proper attention to the physical condition and temperature of the soil that Asiatic beetle grubs can be controlled in soil containing growing azalea plants by applying a mixture of methyl bromide and alcohol diluted in water.

Most of the injury caused to the treated azalea plants was in the raised benches made from the cement slabs. These benches were much tighter than those made from wood and apparently did not permit the methyl bromide gas to escape very readily through the bottom of the benches. In the case of the floor benches, where the soil was from 10 to 12 inches deep, the downward penetration of the gas was not impeded, the gas was not retained in concentrated amounts around the roots and stems, and the plants were not injured. Grubs were killed on the floor bench at a depth of 10 to 11 inches or as deep as they were found.

Tests conducted to kill the Asiatic beetle grubs in fallow soil in the azalea greenhouses showed that satisfactory kill could be obtained with chloropicrin applied 2 cc. per square foot if injected 3 to 4 inches from the surface; with carbon bisulfide at the rate of three-quarter ounce per square foot applied in shallow furrows about 10 inches apart and with a mixture of methyl bromide and methyl alcohol injected into the soil equal to 1 cc. of methyl bromide per square foot. All three materials are probably equally effective in killing the Asiatic beetle grubs. However, the soil cannot be planted until after all the carbon bisulfide or chloropicrin has escaped from the soil which may be 10 days to two weeks for the carbon bisulfide and two to three weeks for the chloropicrin. Soil treated with the methyl bromide may be planted, without injury to the plants, within two to three days after treatment.—1-6-40.

Field Control of the Gladiolus Thrips

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The first known publication on the use of tartar emetic (potassium antimony tartrate U.S.P.) against the gladiolus thrips was that by Richardson (1934). He stated that a 1- to 400-dilution with 3 per cent of molasses was very toxic to adult thrips in laboratory tests. Nelson (1938) found that combinations of tartar emetic (U.S.P.) and brown sugar were noninjurious to gladiolus foliage; that they resulted in thrips control equal to that obtained with paris green and brown sugar, and did not have the deleterious effect on new corm production that paris green appeared to have. Furthermore, the tartar emetic spray could be prepared at less cost than the paris green mixture because of the reduction in quantity of brown sugar used. The spray solution recommended by Nelson contained 4 pounds of tartar emetic and 16 pounds of brown sugar per 100 gallons of water and was the weakest dilution that he tested.

SPRAYS TESTED IN 1938.—During 1938 four tartar emetic-brown sugar spray mixtures were tested to determine the possibility of reducing the quantity of either ingredient. These were compared with the standard spray of 2 pounds of paris green and 64 pounds of brown sugar per 100 gallons of water and with an untreated check Each treatment was replicated six times on each of six varieties of gladiolus. A plot consisted of 50 plants. The experimental procedure was essentially the same as that followed by Nelson and is not discussed

Table 1.—Yield of grade 1 flowers and control obtained from different spray treatments.

SPRAY MATERIAL, POUNDS PER 100 GALS. OF WATER	GRADE 1 FLOWERS		CONTROL, PER CENT
	Number	Per Cent	
Tartar emetic U.S.P. 4, brown sugar 16	229	95.8	93.9
Tartar emetic Tech. 4, brown sugar 16	201	95.3	93.2
Calcium antimony tartrate 4.4, brown sugar 16	206	94.9	92.6
Tartar emetic U.S.P. 4, brown sugar 8	207	92.0	88.4
Tartar emetic Tech. 4, brown sugar 8	230	95.8	93.9
Tartar emetic U.S.P. 2, brown sugar 8	216	92.3	88.9
Tartar emetic Tech. 2, brown sugar 8	238	94.1	91.5
Tartar emetic U.S.P. 2, brown sugar 4	222	94.5	92.1
Tartar emetic Tech. 2, brown sugar 4	226	93.0	89.9
Unsprayed check	68	30.8	—
Minimum significant difference for odds of 19 to 1	49	—	—

further here. The data were interpreted by the method of analysis of variance. Briefly, the following conclusions were indicated: in confirmation of Nelson's results it was found that the tartar emetic sprays were equal to the paris green mixture in effectiveness against thrips and in addition did not burn the gladiolus foliage or adversely affect new corm production. The results showed that 2 pounds of tartar emetic (U.S.P.) and 16 pounds of brown sugar, or 4 and 8 pounds, respectively, gave as good thrips control as the previously recommended dosage of 4 and 16 pounds per 100 gallons of water.

SPRAYS TESTED IN 1939.—During 1939 further reductions in the quantities of both tartar emetic and brown sugar were tested. Eight sprays containing various quantities of tartar emetic and brown sugar were used. Two grades of tartar emetic, U.S.P. and technical, were compared in similar formulas to determine whether they would be equally satisfactory. In addition, one spray in which the tartar emetic was replaced by a calcium antimony tartrate was included to compare its efficiency with the former as a thrips control spray. An unsprayed check was included for comparison.

The experimental procedure was similar to that described by Nelson (1938) and need not be repeated in detail. The two varieties of gladiolus used in these tests were planted May 29. in alternate blocks of 10 plots per block with 50 corms per plot. This arrangement permitted three randomized replications of each treatment on each variety. Beginning June 30, a weekly spray schedule was followed as closely as possible until flowering began on August 15. The flower spikes were classified as grade 1 (uninjured) and grade 2 (thrips-injured) blooms. Richardson and Nelson (1933) demonstrated a direct correlation between the number of thrips present and the degree of injury to the flowers and concluded that the number of grade 1 flowers offers a good index of the effectiveness of a spray.

None of the spray combinations caused any burning or other injurious effects at any time during the tests.

The data on the number and per cent of grade 1 flowers and per cent control are presented in table 1. The per cent control was calculated from Abbott's formula (1925): $(x-y)100/x$, where x is the per cent of grade 2 flower spikes from the checks and y is the per cent of grade 2 spikes from the treated plots.

It can be readily observed that all the sprays gave good thrips control, as measured by the per cent of grade 1 spikes, with no significan tdifference between sprays. The two grades of tartar emetic were equally satisfactory. Calcium antimony tartrate was used at the rate of 4.4 pounds because it contains 10 per cent less antimony than does tartar emetic. Calcium antimony tartrate is slowly soluble in water and must be finely powdered so that it will go into solution readily or hot water must be used. Tartar emetic is more readily soluble but it also should be finely divided to accelerate solution.

The cost per 100 gallons of the spray containing 2 pounds of tartar emetic, technical grade, and 4 pounds of brown sugar (table 1) is $0.95 as compared with $2.68 for the spray containing 4 pounds of tartar emetic, U.S.P. grade, and 16 pounds of brown sugar, the formula recommended by Nelson. The cost of the other formulas given may be readily calculated from the prices given.*

* Tartar emetic U.S.P. cost 43¢ per lb., technical 35½¢; calcium antimony tartrates 28¢ and brown sugar 6¢.

OTHER SPRAYS TESTED IN 1938.—Other workers have experimented with a large number of spray combinations against the gladiolus thrips, but those discussed below had not previously been tested. Table 2 presents the data obtained from a comparison of three derris sprays with the standard paris green-brown sugar combinations and with an untreated check. The flowers were graded and the per cent control calculated as explained previously.

Table 2.—Yield of grade 1 flowers and control obtained from various derris sprays as compared with paris green plus brown sugar.

MATERIALS IN 100 GALS. OF SPRAY	GRADE 1 FLOWERS		CONTROL, PER CENT
	Number	Per Cent	
Paris green, 2 lb., brown sugar, 64 lb.	161	83.0	80.9
Derris powder* 4 lb., 6 oz.; peanut oil 1 gal.; sodium oleyl sulfate 1 pt.	94	55.6	50.0
Derris powder 3 lb., 4½ oz.; peanut oil 1 gal.; sodium oleyl sulfate 1 pt.	85	47.0	40.3
Derris powder 3 lb., 4½ oz.; sodium lauryl sulfate 6 oz.; varnish 1 pt.	76	38.8	31.1
Untreated check	23	11.2	—
Minimum significant difference for odds of 19 to 1	37	—	—

* The derris powder in all sprays contained 3.8 per cent of rotenone.

An examination of the data shows that the three derris sprays did not differ in effectiveness and were not satisfactory for thrips control. They were all inferior to the paris green-brown sugar mixture, as measured by the number of grade 1 spikes produced, but were better than no treatment. In addition, the two sprays containing peanut oil retarded the growth and flowering of the plants and adversely affected corm production.

Table 3 shows the results obtained from other sprays tested on a small scale.

It is apparent that none of the spray combinations was satisfactory from the standpoint of thrips control. In addition, the sprays containing powdered karaya gum left appreciably greater deposits of material in droplets on the gladiolus foliage than did the brown sugar combinations.

In spite of these heavy deposits the percentages of grade 1 flowers were lower than in the plots treated with the same quantity of tartar emetic and with the spreader sticker sodium oleyl sulfate plus synthetic resins, which wet the foliage and left a uniform film. Both these were less effective than the tartar emetic-brown sugar sprays that are applied as droplets.

Table 3.—Yield of grade 1 flowers and control obtained from different spray combinations.

SPRAY MATERIAL, PER 100 GALS. OF WATER	GRADE 1 FLOWERS		CONTROL, PER CENT
	Number	Per Cent	
Variety Virginia			
Tartar emetic 4 lb.; powdered karaya 25 oz.	23	21.1	10.8
Tartar emetic 4 lb.; sodium oleyl sulfate plus synthetic resins 1 pt.	44	51.8	45.5
Nicotine sulfate (40%) 1 qt.; powdered karaya 25 oz.	22	18.5	7.9
Untreated check	38	11.5	—
Variety Los Angeles			
Tartar emetic 4 lb.; powdered karaya 25 oz.	70	36.1	33.6
Untreated check	2	3.7	—
Variety Brilliant			
Tartar emetic 4 lb.; sodium oleyl sulfate plus synthetic resins 1 pt.	20	26.0	14.7
Untreated check	10	13.2	—
Variety Alice Tiplady			
Nicotine sulfate (40%) 1 qt; powdered karaya 25 oz.	52	25.6	15.1
Untreated check	19	12.4	—

CONCLUSIONS.—The results indicate that the quantities of tartar emetic and brown sugar previously recommended may be reduced considerably without reducing the efficiency of the spray. Both U.S.P. and technical grades of tartar emetic were satisfactory, with a price differential in favor of the latter. A calcium antimony tartrate spray gave results comparable with those for a tartar emetic spray of equal antimony content and was appreciably cheaper. Tartar emetic in combination with powdered karaya or sodium oleyl sulfate plus synthetic resins was unsatisfactory. Nicotine sulfate plus karaya was also unsatisfactory. Derris powder in combination with peanut oil and either sodium oleyl sulfate or varnish in combination with sodium lauryl sulfate gave poor control. The spray containing peanut oil retarded the growth and flowering of the gladiolus plant.—1-6-40.

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Recent Changes in Agriculture and Their Effect on Insect Problems

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INTRODUCTION.—There has been no other period in the history of American agriculture when broad changes in theory and practice have been so extensive and rapid as in the past few years. This period has seen the first attempt at the formulation of a broad, coordinated agricultural program planned to include the various phases of agriculture considered from the standpoint of the reactions of the component parts on the whole. Extensive changes in agricultural practice are being made because of a greater appreciation of the importance of preventing soil erosion and maintaining soil fertility, of the necessity for wild life conservation, of the need for reasonable adjustment of agricultural supply to demand and of the value of proper land use. Insect control is one of the important factors which must be considered in such a broad program. Irrespective of personal opinions as to the wisdom of the broad policies of agricultural readjustment and as to their present and probable future results, the responsibility devolves upon all entomological workers to consider the effects of these changes on entomological practice.

Possibly entomologists have participated too little in the formulation of specific procedures aimed at achieving the broad objectives of the agricultural program. Many practices which run counter to best practices for insect control have been urged to achieve these objectives. In some instances modifications should be made in deference to the importance of the entomological aspects of the problem, while in others entomological practice should be modified to meet the new conditions. Which action should be taken will depend entirely upon the specific situation as revealed by a careful analysis of the objectives and of the entomological and other effects. In any event these procedures call for intelligent consideration to determine whether minor modifications may be made to provide for insect control without defeating important objectives, whether control recommendations may be modified without serious loss, and whether entomological recommendations which may be in conflict are actually based on sound, tested research information or have merely grown up over a period of years because they were thought to be good practice. In many instances, reconciliation between the general agricultural program and the needs for entomological control will call for research to adapt entomological procedure to the changed conditions. Possibly many recommendations for insect control have been based in the past to too large an extent on considerations involving only insect control and have not taken adequately into consideration other values and interests.

Attention should be directed to the possibility that the attainment of certain objectives of the program or that methods which may be utilized to achieve them may be of distinct benefit in reducing the population of harmful insects. The advantages which may be derived should be evaluated as well as the disadvantages.

There are also many changes which are occurring which have no particular relationship to a general national agricultural policy but which are of considerable importance in affecting entomological practice and outlook. In his presidential address to the American Association of Economic Entomologists at Richmond in

1938, J. J. Davis, reviewed in considerable detail a number of changes affecting entomology, which have taken place in recent years, in much greater detail and more thoroughly than will be possible or desirable in this presentation. Rather than attempting to make an exhaustive review of changes in agriculture affecting insect problems, the remarks in this paper will be confined primarily to some of the changes which are a result of the national agricultural program.

SOIL CONSERVATION.—The desirability of a sound program for soil conservation, including both the conservation of fertility and prevention of soil erosion, is not open to question. Preservation of the soil and its fertility is the foundation of all sustained agriculture and must be given primary consideration in any forward-looking agricultural program. Many practices leading toward soil conservation have been recommended, urged, and adopted through the operations of the Agricultural Adjustment Administration, the Soil Conservation Service, and other federal and state agencies. Some of these practices have no entomological implications; others may profoundly affect insect abundance and consequent damage. It does not follow, however, that such practices as do increase insect abundance are in themselves bad. Not infrequently slight modifications may be made which will eliminate the undesirable entomological effects and still achieve the desired result. Some soil conservation practices will be mentioned and their entomological implications briefly discussed.

STRIP FARMING.—The effect of strip farming on insect abundance varies widely from area to area and even from season to season. Its effects are particularly noticed and will probably be of continuing importance in areas where grasshoppers are serious and particularly in areas which have a history of repeated annual grasshopper outbreaks. It is noted that strip farming and its effect on grasshopper populations will be discussed later in the program so that it will not be further considered here.

In areas where chinch bugs are endemic or during years of widespread chinch bug infestation, strip farming involving small grains and corn or sorghum greatly increases the hazard from chinch bugs and materially increases the cost of their control. Strip farming, with these crops should be recommended in areas of frequent chinch bug damage only after consideration of the hazards involved.

Reports have been received of the increase in certain species of cutworms, particularly the variegated cutworm and other migratory species, as a result of strip cropping with leguminous crops, and such cropping—particularly with legumes and corn or other row crops and small grains—may have a tendency to increase materially the damage resulting from these species.

These are only a few of the cases where insect abundance may be increased by this practice. It does not necessarily follow, however, that this should result in condemnation of strip farming as such. Sufficient information should be made available to permit adequate evaluation of the possible entomological hazards from strip farming in a given area and to provide means whereby undue hazard created by the practice may be avoided. In many instances sufficient information is not now available to determine the hazards resulting from strip cropping or other similar practices, or to suggest means of avoiding them. It is important that such information be accumulated as rapidly as possible, both through research agencies and through observations made by the extension entomologists under conditions as they actually occur in the field following the introduction of strip farming with various crops, in various localities, and with various insect species.

MAINTENANCE OF SOIL COVER.—An important feature of soil conservation, both from a fertility and an erosion standpoint, involves the maintenance of sufficient cover on the land to prevent undue washing, through leaving debris and crop remnants on the field or through the planting of cover crops.

The utilization of small grains as cover crops in the central great plains region and in the southern portion of the Upper Mississippi and Ohio Valley regions involves certain hazards from increase in hessian fly populations. This may be more marked if moist conditions more favorable to hessian fly development prevail. Cover crops of wheat, barley, or rye, planted previous to the safe date for avoiding hessian fly attack, should not be recommended in any areas where hessian fly is a serious problem without careful consideration of the hazards involved.

The combination of fallow lands maintaining stubble and volunteer wheat and the early planting of a cover crop such as wheat presents an ideal situation for rapid multiplication of hessian fly and the development of extensive outbreaks.

Certain cover crops such as grasses and legumes are particularly favorable to the development of a number of species of cutworms and may result in extensive and severe damage when these crops are followed by row crops, including corn. In certain western areas the western army cutworm and the pale western cutworm are both very important crop pests, particularly of small grains and legumes. The common control method for both these species is clean summer fallowing during the season prior to the planting of small grains. Leaving stubble and weed growth on the land in order to prevent erosion or the utilization of certain cover crops allows these insects to increase greatly in numbers. Recommendation for the utilization of specific cover crops should be made only after full consideration has been given to the extent and importance of cutworm infestation.

A recent study completed by the Bureau of Entomology and Plant Quarantine indicates that abnormal conditions for survival of certain species of wireworms may be developed through the growing of red clover and of certain other cover crops. In the instance of other crops grown in rotation, it has been shown that their effect leads to stationary population or even to slight decreases. It is not surprising that in certain areas growers are loath to adopt the use of winter cover crops as a soil conservation practice when they have been led by experience to believe that such crops cause an increase in wireworm infestation. It is the opinion of a number of growers in southern California that the use of green manure crops as a cover materially increases wireworm damage. This has resulted in the failure of a number of the farmers to participate in the Agricultural Adjustment Program because they feel that the wireworm damage subsequent to the growing of the cover crop will far outweigh any benefit that they may receive from the program. On the other hand, damage from certain species of wireworms in the Southeast is eliminated to a large extent by the planting of suitable cover and soil-building crops. The role played by cover crops in controlling wireworm populations needs further study but it is certain that, in areas where wireworms are important, cover crops should not be recommended unqualifiedly before their effect on wireworm development is reasonably well known.

Retention of crop remnants and stubble on soil between the harvesting of one crop and the planting of another is important in many instances as an erosion prevention measure. This practice runs counter to the recommendations given for the control of many insects which call for the early destruction of crop remnants, including stubble, and, in many instances, for fall disturbance of the soil. The destruction or proper treatment of plant debris is of particular importance in the control of such insects as hessian fly, wheat jointworm, wheat strawworm, European corn borer, and cotton boll weevil, among others.

SOIL COVER.—The utilization of soil cover as a means of prevention of erosion deserves the careful consideration both of entomologists and soil conservationists in the working out of a program which will give a maximum insect control and soil protection. Careful consideration of a few specific insect problems indicates that both important objectives may frequently be attained by the proper timing of operations and the proper selection of method. Because many of the field crop insects can be controlled on a practical basis only by cultural methods, a reconciliation of the two programs is particularly important from the standpoint of field crop insect control. The Bureau of Entomology and Plant Quarantine and the Soil Conservation Service have discussed recently the burning of field margins and the early destruction of stalks in relation to boll weevil control and prevention of erosion, with the object of working out adjustments meeting the needs of both programs. Certain state entomologists are doing an excellent job in working out program adjustments with the Soil Conservation agencies, in both soil conservation and insect control, which will give the maximum benefit. Closely coordinated consideration of problems of this nature should certainly be encourged and every effort should be made to bring to the attention of soil conservationists and entomologists the possibility of devising agricultural plans

meeting the needs of local areas. These are not problems which can be satisfactorily attacked on a broad national basis but must be considered from a local standpoint, where specific consideration may be given to the crops grown, the agricultural needs, and the important local insect problems.

TREES AND SHRUBS IN CONTROL OF EROSION.—Extensive utilization of plantings of various trees and shrubs to retard or prevent erosion, particularly in gullies and hilly, abandoned land, is being made in various parts of the country as a part of the soil conservation program.

The use of certain trees and shrubs for the control of erosion may be of great importance from the standpoint of increasing the pest risk hazard when plants are selected for this purpose which are important hosts of insects attacking cultivated plants. There is the possibility of forming uncontrolled reservoirs for pests of cultivated fruit and shade trees which may build up large populations for infestation of commercial plantings. This may be true, for example, where apricots, plums, prunes, and peach trees are used for gully erosion control in areas where these or related crops are grown on a commercial basis. There is also the possibility, through these plantings, of bridging barriers to the further natural spread and extension of insect pests which now occur due to discontinuous distribution of certain commercial plant species.

Another entomological problem presented by utilization of trees and shrubs for erosion control involves the control of insect pests of these species to make them more effective for the purpose intended. For example, one of the trees most suitable for planting in certain large sections of the United States would be the black locust if it were not for the severe injury from locust borer suffered by this species.

WILD LIFE CONSERVATION.—The increased interest in the conservation of wild life and the attempts to provide adequate winter cover and food for various species of birds and game animals run counter, in some respects, to common recommendations for insect control. It has been considered sound entomological practice to clean up fence rows and corners, and to eliminate as far as possible weedy growths and similar places suitable for winter hibernation. These places also provide suitable winter cover and food for wild life. Burning of cover has been recommended for the control of certain species of farm pests, including chinch bugs, ticks, boll weevils, etc. The desirability of wild life conservation suggests a careful re-examination of all recommendations for burning to determine whether they are necessary and just how effective they are in accomplishing desired results. No doubt in many instances recommendations for burning have been made purely on the basis of destruction of favorable overwintering quarters without any actual evaluation having been made of the results of this in terms of population reduction. In some instances, restricted and controlled burning may be desirable and necessary, but it should not be recommended indiscriminately or without adequate factual basis to support it. On the other hand, insect control, particularly of grasshoppers, has been emphasized by wild life conservationists as of importance in conserving food for wild birds. Elimination of Gulf Coast tick, which may involve burning, would remove an important predisposing cause of screwworm infestation in deer and other wild animals.

Just what effect retaining adequate cover for wild life would have on crop insect populations is a moot question and one which deserves the careful consideration of research entomologists and conservationists.

PROPER LAND USE AND THE RETIREMENT OF UNPRODUCTIVE LANDS.—The tremendous abandonment, during the last few years, of farming lands because of drought and of inadequate financial return, as well as the retirement of lands from cultivation under the resettlement program, presents a serious problem in insect control, at least during the adjustment period. Lands recently abandoned form ideal breeding places for a large variety of agricultural pests, one of the most important of which is grasshoppers. Just how the control of insects on these lands can be best handled during the reversion process is a serious consideration, particularly in the northern great plains states. Any process whereby the reversion to good grass lands can be speeded up should be given encouragement because of the reduction in the entomological hazards from these lands.

In this instance, the soil conservation and land-use programs fit in ideally with the needs from an entomological standpoint.

It may be said that, as a general thing, range land which is well-grassed, with a minimum of weeds, is not an important insect hazard. It is primarily during the reversion process of abandoned land and on depleted ranges that the pest risk exists in an exaggerated form. Certainly the removal from cultivation of marginal lands, on which the return is so small that approved insect control practices cannot be adequately followed, is a step in the right direction. The formation of grazing districts and other measures, aimed at obtaining the maximum utilization of grazing lands but at the same time preventing over-grazing, fits in ideally with this program in preventing the depletion of ranges and pastures, and in bringing about the most rapid return to good grass cover of depleted ranges and of lands recently taken out of cultivation.

The process of improving range and pasture lands may involve the use of introduced grasses. The relative susceptibility of these plants to grasshopper and other range insect attacks, and their resistance to infestation by hessian fly, strawworm and other crop pests which attack grasses are of interest to entomologists and conservationists alike.

As a part of the program for making the best use of lands considerable attention has been directed toward conservation of forests and reforestation, with an increasing appreciation of the importance of insect control in obtaining and maintaining good forest stands. A number of insect problems have been presented, particularly in the control of insects in forest nurseries and in new plantings of forest trees. The attempt to establish forest plantings as shelter-belts has also been accompanied by insect losses. Most of these problems are not new but have assumed increasing importance because of the expanded program.

CROP INSURANCE.—The recent provision for Federal crop insurance on wheat, and its possible extension to other crops, presents a problem in evaluating insect losses as a factor in establishing rates. Experience with actual losses occurring over a period of years will provide a sounder basis for insurance costs than is possible on the basis of any information available at the present time. The importance of developing more adequate means of evaluating and recording insect losses has been emphasized by the demand for information in connection with this program. It is likely that information obtained through settlements on crop insurance policies will be a valuable source of data on damage resulting from insect attack in the future. If such information is to be accurate, however, it presents an important extension problem. The fact that the crop insurance program is handled very largely through local committees in the counties, who make recommendations on policy adjustments and determine the cause of the loss, indicates the need for extension work which will reach the committeemen and enable them more adequately to determine the causes of loss, with particular reference to the species of insects involved.

Above all is the importance of establishing adequate insect control practices as a concomitant to the development of the crop insurance program, both to reduce the losses which must be covered under the program and to reduce the insurance rate to the grower. Crop insurance should offer an important incentive to the grower to apply the recognized methods of control, as the policies contain a provision whereby they may be invalidated if the farmer has not employed generally practiced methods of protecting his crop from insect and other losses.

EVER-NORMAL GRANARY.—The storage of large quantities of wheat and corn on the farm as a part of the Ever-Normal Granary Program is presenting serious problems in the control of stored product insects. Infestations by these insects will probably be most severe during the times when the largest amount of grain is in storage, because more abundant crops and maximum storage of high-moisture grain will occur during periods of favorable rainfall. These conditions are also favorable for the increase of insect infestations.

The immediate responsibility for approving suitable storage failities and for checking proper insect control procedure devolves largely on local committees. An important extension problem is presented in educating the local people responsible for handling the Ever-Normal Granary Program in determining satisfactory stor-

age and in recognizing and controlling insect infestation.

The extensive increase in farm storage, with the long holding period and the possible building up of reservoirs of infestation on the farm which have not previously existed, presents important research problems in control. Objections which have been raised to the use of carbon disulphide because of its fire hazard and its limitations as to effectiveness indicate the need for additional research on fumigants for farm use, as well as on methods of handling fumigations under the various farm storage conditions.

ADJUSTMENTS OF SUPPLY TO DEMAND.—The need for insect control under conditions of surplus production and in the face of a program designed to reduce surpluses of certain crops has been frequently questioned. The whole system, however, calls for an equitable reduction of production throughout the major producing areas and further demands considerable accuracy in forecasting probable production. Any factor, such as severe insect outbreaks, which might tend seriously to disrupt the equitable distribution of production and to inject an unpredictable factor into production estimates, would seriously interfere with the proper carrying out of the adjustment program. The need for reduction of insect losses to a minimum to avoid disruption of the program is thus emphasized.

Coupled with the adjustment of supply to demand is an attempt to raise per-acre income. The production of crops for the consumption of insect pests adds tremendously to the cost and may seriously reduce the income per production unit. The adequate control of insects such as grasshoppers, chinch bugs, boll weevil, and hessian fly, which may seriously reduce production and increase its cost, is an essential in establishing a stabilized agriculture, and places a serious responsibility on research and extension entomologists to provide the best means for control and to put them into practice.—1-6-40.

Grasshoppers, A Factor in Soil Erosion in Michigan

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The following material has been used as basic information in presenting the broader aspects of the grasshopper problem to the County Agricultural Agents and Farmers in the grasshopper area in Michigan. The county agents have had an active part in the annual surveys and appreciate the importance of the grasshopper problem as a factor in soil erosion. The farmers on the lighter soils seldom realize what has happened and the situation is being met by bait spreading demonstrations and square mile control demonstration areas in addition to the lecture, radio and news story approach used for several years.

The more severe grasshopper infestations have occurred in Michigan in areas where the lighter soils predominate. The heavily infested areas consist mainly of abandoned cleared farm lands and cut over areas which have been burned over by forest fires. These latter areas were widely used as pasture for cattle, usually on an open range basis, with some land fenced.

Widespread severe grasshopper infestations occurred in Michigan in 1917–18–19 and again in 1933–34–35. Following these periods, marked changes occurred throughout the infested territory and considerable areas of land went out of agricultural use. In some instances, the grass was replaced by weeds and later by dewberries, sweet fern and poplar. In other cases, the loss of the grass as ground cover exposed the soil to the influence of the wind. Before other vegetation could get started, blowouts occurred wherever the wind attained sufficient velocity to carry the sand. In more protected sites the development of moss in the "hopper" droppings, which accumulated in small depressions, spread and in many cases formed a temporary bond for the soil surface.

Severe wind erosion and in some cases water erosion has occurred throughout the grasshopper area in the western portion of the state and in the other areas where the sandy soil types prevail. This denuding of the ground has been watched as it progressed on many fields in connec-

tion with the grasshopper population survey work. Small blowouts have been observed to start and grow in two years to cover several acres in old fields where a good stand of grass had occurred and where a fair stand remained beneath and on the north side of thick trees or tall brush lines.

The grass growing in the shadows of the trees was just as heavily grazed by livestock as that in the open at the start of the infestation and received more attention later as there was no grass elsewhere. In spite of a concentration of grazing by cattle the blue grass persisted in the shaded spots where it had to compete with the trees for moisture. In the open, where the sunlight permitted the "hoppers" to feed more heavily and probably later in the season, the grass disappeared.

Residual, natural, blue grass seeding could not occur on these sites as long as the grasshoppers were present in large numbers. Where control, consisting of poison bait, was used over large areas in Wexford County by the Forest Service in 1935 and 1936, the limits of their holdings were well defined in 1939 by the differences in ground cover. More rainfall than usual gave the grass a chance to develop rapidly wherever there was any to develop, and where the grass hopper population had been reduced to a normal level.

Overgrazing by livestock is conducive to soil erosion, but when accompanied by severe grasshopper infestations with populations of from 15 to 40 grasshoppers per square yard, this condition is much aggravated. In many cases, overgrazing alone would not have caused the condition that exists as the cows would have starved out long before the grass roots were all dead.

EFFECTS OF EROSION ON GRASSHOPPER POPULATIONS.—The relative abundance of the various species of grasshoppers in Michigan changes as the ground cover becomes different. The predominating species on many sites in 1934 was *Camnula pellucida;* the following year, 1935, this species took second place in importance on many sites where grass was scarce. *Melanoplus mexicanus* became the first ranking species and was able to persist where no grass was to be found after mid-summer. They fed on milkweed, moss and other suitable vegetation that was available on the various sites and were able to deposit sufficient eggs to maintain a relatively high population level.

As the denuding progressed and was followed by wind action on the soil, *Ageneotettix deorum* found conditions more suitable. This species assumed first place in numbers and importance in many areas where blowouts occurred. The egg laying habits of the species were favored as the eggs are commonly found in bare sandy areas, mainly blowouts and washes, about small clumps of grass. The grasses include the so-called wire grasses that are not commonly used for food. The eggs are most often found in the northern edge of such areas where the exposure to the sun is the greatest.

On better sites where the grass was never completely killed out, *C. pellucida* sometimes retained first place in numbers and in others resumed first place as soon as a season of more favorable grasshopper weather occurred. The greatest single factor influencing population levels and the relative abundance of the economic species still seems to be the weather. The most critical time of year is the hatching period. When changeable weather occurs the young "hoppers" are often hatched on warm days and die if cool weather follows.—1-6-40.

Evaluation of Insect Damage under the Crop Insurance Plan

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At the present time the only crop insurance which is actually in operation is that for wheat. This applies only so far as federal insurance is concerned. In a few cases crops may be insured by private insurance companies, but these are all, so far as can be learned, special cases, and none of the private companies has any general crop insurance plan which it is using at this time.

Under the wheat insurance plan now in operation, the crop may be insured for a loss of either 50 per cent or 75 per cent of the value of the crop. There is no provi-

sion for insuring losses amounting to more than 75 per cent of the crop. Under the present plan there is no provision for evaluating insect damage as such, or for that matter, damage caused by any one of the many factors that may bring about a reduction in the wheat yields. The loss for any one season is determined from the average yield of wheat on the particular farm for a period of years. This is also modified by the average yield on all farms in the county in which the insured field is located. The average yield for the farm has been determined as the average for the period for that farm from 1930–1935 inclusive. This is also adjusted on the average 10-year yield in the county for the period of 1926–35. During the past year there was some difference in the way in which the average yield for the farms was determined. In some cases the yield was determined by the average during the period of the past 17 years. This method was in general use in some parts of Illinois during 1939.

As will be seen, under this plan the loss might be due to the drouth, hot winds, hail, insects, floods, and, under certain conditions, to damage from livestock or a number of other factors. Negligence of any essential part of the wheat growing operation on the part of the owner ordinarily cancels the insurance. Arbitrary factors that have been suggested for determining negligence on the part of the co-operator are: (1) If he sows before the fly-free date or more than a week after the general average date of seeding in the community; (2) If he fails to set up grain shocks after a rain or wind; (3) If he does not keep gates closed around grain fields and livestock comes through the open gates and causes damage; (4) If he does not thresh his shocked grain within two months after cutting it, unless rainy weather has prevented this for two weeks or more during that time; (5) If he does not have sufficient operating capital or credit; (6) If he adopts a cropping policy counter to recommendations from county farm advisers or other qualified individuals; (7) If he plants varieties not adapted to his soil or climatic environment.

If it is found that any of the above factors apply to a particular farmer, he can bring no claim for benefits from crop insurance, as he will be held to be a negligent cooperator.

Under this plan it is of course important that a very definite method be set up for determining average yields. According to Dr. Walter J. Wills, a graduate student who has made a careful study of crop insurance as now in force, the best method for determining this is to get the data on the average yield for wheat for the years for which such data are available, the data to be taken for at least a six-year, and better, for a ten-year period. The average yield thus determined is placed on an index basis; *i.e.*, the county average for the given crop for the given year will equal 100. For a given field the index might thus be for wheat, 93, or 108, or 110, or 75. Then to determine the average yield for a given farm for a certain period, one takes the actual yields for the field when it was in wheat, and multiplies the county average by the productivity index. This gives the approximate yield for the field.

Under this system, then, there is no provision for, or attempt made to evaluate, insect losses for the ten years 1909–19. Insect losses to wheat in the northeast central states were, as determined by Dr. Wills, 3.88 per cent; in the west north central states, 2.02 per cent; in the south central states, 2.67 per cent. For these same years the total crop loss from all causes averaged a little above 30 per cent. In other words, insects were responsible for only about 10 per cent of the total loss to the wheat crop.

While no insurance plan is definitely enforced for other crops, the agricultural economists state that it is probable that about the same system would be worked out as has been worked out for the wheat crop, *i.e.*, it would not be necessary to evaluate insect losses as such. It is quite obvious that it would be much easier to carry out such a plan than it would a plan under which an attempt is made to give a definite value to the losses caused by each of the many adverse factors. The provision for cancelling the insurance, if it is determined that the cooperator has been willfully negligent in following the best suggested methods and practices, would seem to guard against his willfully failing to take the usual precautions to combat insect. Under the provisions now in force it would seem that a failure to use poison bait for the control of grasshoppers and to take recommended precautions against the clover root worm, the southern corn root worm, or the white

grub would be considered as willful negligence on the part of the cooperator, and would therefore automatically cancel his insurance. On the other hand, if an insect outbreak occurred of which he was not warned in advance and in such a way that he could not take measures to stop the damage, it seems that he should receive compensation from his crop insurance policy. Examples of damage of this nature are heavy infestations of corn ear worm, destruction of crops by migratory swarms of grasshoppers, damage by wireworms, or damage by second brood chinch bugs if he has not willfully planted strains of corn which were known to be highly susceptible to these insects.

On the whole, it would seem that the present insurance plan as operating for wheat makes provision for taking care of insect losses in wheat in a way that is quite satisfactory and workable.—1-6-40.

The Effect of Arsenical Grasshopper Poisons Upon Pheasants

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Wholesale use of arsenical baits in grasshopper control campaigns has served to keep alive the question of whether or not these baits are a menace to wild life. This is particularly true of upland game birds, due to the stocking programs in progress in various states. The ringneck pheasant is of special interest because of its adaptability and popularity as a game bird in extended areas.

The effects of poisons on gallinaceous birds have been discussed by several writers but the number of critical investigations in this field is surprisingly small. Whitehead (1934) gave a good review of the literature and made extensive tests with domestic chickens. He also conducted feeding tests with quail and nestling song birds. Wilson and Holmes (1936) reported on an exhaustive study along similar lines, also with chickens. Zimmerman (1938) has summarized most of the meager information available on upland game bird poisoning. The general conclusion indicated by these and other papers is that gallinaceous birds are relatively immune to grasshopper poisoning as recommended and practiced.

This paper is a report on a study intended to demonstrate whether or not grasshopper control practices are detrimental to the ringneck pheasant.

PROCEDURES.—Four pairs of young pheasants (43 days old at start of experiment on August 9, 1939) were confined in screen cages of $3 \times 2 \times 2\frac{1}{2}$ feet dimensions. These cages were located under the north sides of two apple trees, so as to afford protection from direct sunlight. With the exception of pair 1, the birds were on dirt up to August 30 after which date the cage floors were kept covered with a layer of finely-crushed limestone. Pair 1 was similarly housed up to September 7, after which they were on an eighth inch mesh screen floor.

These birds were fed daily throughout the experiment and fresh water was kept constantly before them. The "standard diet" consisted of two standardized *Gold Medal* feeds upon which the birds had been fed previous to the start of the tests. These are listed as "mash" and "grain" in figure 1 for the sake of brevity. Mash refers to *Gold Medal Turkey Builder*, guaranteed to contain not less than 24.0 per cent crude protein, 4.5 per cent crude fat, 40.0 per cent nitrogen-free extract, and not more than 6.5 per cent crude fiber. Grain refers to *Gold Medal Developing Grain*—cracked yellow corn, wheat, kafir and milo, guaranteed to contain not less than 10.0 per cent crude protein. Crushed limestone served as grit.

Various combinations of arsenical baits and grasshoppers poisoned with these baits were made with the ingredients of the standard diet during the course of the experiment. Details are given in figure 1 and table 1. The "U.S.D.A. standard" bait had the following formula: 3 parts bran, 1 part sawdust, 2 quarts liquid sodium arsenite (4-pound material) per bulk of carrier equal to 100 pounds bran, $1\frac{1}{2}$ gallons cane molasses, and 10 to 12 gallons water. This bait is used by government entomologists as a basis of comparison for experimental baits in field tests. It is considered more palatable than many baits in commercial use, due to the high proportions of bran and cane molas-

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station as a contribution from the Department of Economic Entomology.

ses. All "poisoned" hoppers had had access to this bait and were dead or dying, presumably from arsenical poisoning. Several species of grasshoppers were used but *Melanoplus mexicanus* was predominant. The oil-bran bait is one that has proven particularly effective in cage and field tests in Wisconsin during the

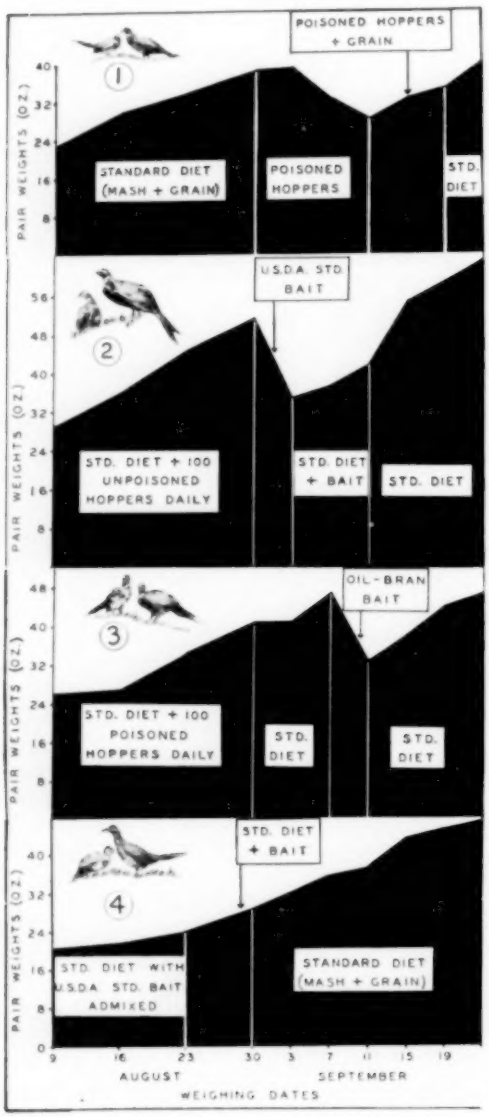

FIG. 1.—Weight fluctuations of pheasants in arsenic tests.

past two years. The formula is: 25 pounds bran, 1 pound mono-calcium arsenite and 2 quarts of *Iso-Vis 20-W* oil.

All birds were weighed individually at weekly intervals from August 9 to August 30, and at four-day intervals from August 30 to the end of the experiment on September 23. On September 24 they were photographed and six were released on that date. The larger bird of pair 1 and the female of pair 2 were killed and autopsied on September 26. The former was a greedy individual that had eaten more than half of the 5,190 poisoned hoppers fed to this pair between August 30 and September 19, while the latter showed the most severe effects from eating poison bait when pair 2 was on the exclusive bait diet between August 30 and September 3. The vital organs and tissues of these birds were examined macroscopically for gross pathological changes and subsequently analyzed chemically to determine the amounts of arsenic present within them by the procedure recently advocated by Cassil & Wichmann (1939).

DISCUSSION.—Both individuals of pair 1 gained consistently on the standard diet from August 9 to August 30. The only feed provided from August 30 to September 3 was 735 poisoned grasshoppers, but these birds scratched considerably during this period and uncovered some grain that had been buried in the crushed limestone. During the next eight days, September 3 to 11, they received a total of 2,855 poisoned grasshoppers as their exclusive diet. The weight loss during this interval was thought to be due mainly to lack of sufficient food, rather than to arsenical poisoning. During the subsequent eight day period, both birds made satisfactory gains when fed *Gold Medal Developing Grain*, supplemented with 200 poisoned hoppers daily. This pair received a total of 5,190 poisoned grasshoppers over a 20 day period, but no deleterious effects were evident, aside from weight losses that were promptly regained.

Pair 2 consisted of comparatively large individuals which gained rapidly from August 9 to August 30, during which time they received 100 unpoisoned live grasshoppers daily. From August 30 to September 3 they were on an exclusive diet of the U.S.D.A. standard bait. The female fed moderately on this bait at first and became very ill. The male was more wary of the bait and little feeding was done by either bird after the first day. Undoubtedly the losses in weight were due partially to lack of food, although

arsenical poisoning was probably in part responsible. These birds were put back on the standard diet on September 3 but a handful of the poison bait was scattered over the cage floor each day from September 3 to September 11. The birds ignored the bait and soon began to gain weight rapidly.

Pair 3 likewise gained considerable weight between August 9 and August 30, during which period they received 100 poisoned hoppers daily as a supplement to the standard diet. The August 16 weighings suggest that some slight physiological adjustment to this amount of arsenic intake may have been necessary. They received only the standard diet from August 30 to September 7, when they were put on an exclusive diet of the oil-bran bait. For the four-day period during which they were kept on this feed they showed a marked loss of weight. They fed only sparingly on the bait, particularly after the first day, and evidently

Table 1.—Record of four pairs of caged pheasants under test from August 9 to September 23, 1939 (birds 43 days old on August 9). Door County, Wisconsin.

Pair	Daily Ration for Period	Weight (oz.)			Change		
		♂	♀	Total	♂	♀	Net
	August 9 to 16						
1	Standard diet.*	12	11	23	—	—	—
2	Standard diet plus 100 unpoisoned hoppers.	16	13	29	—	—	—
3	Standard diet plus 100 poisoned hoppers	12	14	26	—	—	—
4	Standard diet with U.S.D.A. standard bait, admixed.	11.5	9	20.5	—	—	—
	August 16 to 23						
1	Standard diet.	16	14	30	4	3	7
2	Standard diet plus 100 unpoisoned hoppers	19	17	36	3	4	7
3	Standard diet plus 100 poisoned hoppers	13	14	27	1	0	1
4	Standard diet with U.S.D.A. standard bait, admixed.	12	9.5	21.5	0.5	0.5	1
	August 23 to 30						
1	Standard diet.	17.5	16.5	34	1.5	2.5	4
2	Standard diet plus 100 unpoisoned hoppers	24	21	45	5	4	9
3	Standard diet plus 100 poisoned hoppers	17	17.5	34.5	4	3.5	7.5
4	Standard diet plus U.S.D.A. standard bait, scattered	13	11	24	1	1.5	2.5
	August 30 to September 3						
1	Exclusive diet of poisoned hoppers (average 184 per day).	20.5	18	38.5	3	1.5	4.5
2	Exclusive diet of U.S.D.A. standard bait.	28	23.5	51.5	4	2.5	6.5
3	Standard diet without supplements.	21.5	19.5	41	4.5	2	6.5
4	Standard diet without supplements.	16	12.5	28.5	3	1.5	4.5
	September 3 to 7						
1	Exclusive diet of poisoned hoppers (average 270 per day).	20.5	18.5	39	0	0.5	0.5
2	Standard diet plus U.S.D.A. standard bait, scattered.	19	16	35	−9	−7.5	−16.5
3	Standard diet.	21	20	41	−0.5	0.5	0
4	Standard diet.	17.5	14.5	32	1.5	2	3.5
	September 7 to 11						
1	Exclusive diet of poisoned hoppers (average of 444 per day).	17	15	32.5	−3.5	−3	−6.5
2	Standard diet plus U.S.D.A. standard bait, scattered.	23	14.5	37.5	4	−1.5	2.5
3	Oil-bran bait exclusively	25	22	47	4	2	6
4	Standard diet.	19	16.5	35.5	1.5	2	3.5
	September 11 to 15						
1	"Grain" plus 200 poisoned hoppers	16	12	28	−1	−3.5	−4.5
2	Standard diet without supplements.	26	16	42	3	1.5	4.5
3	Standard diet without supplements.	17	16	33	−8	−6	−14
4	Standard diet.	20	17	37	1	0.5	1.5
	September 15 to 19						
1	"Grain" plus 200 poisoned hoppers	18.5	14	32.5	2.5	2	4.5
2	Standard diet.	32	23	55	6	7	13
3	Standard diet.	19.5	19	38.5	2.5	3	5.5
4	Standard diet.	23	20	43	3	3	6
	September 19 to 23						
1	Standard diet without supplements.	19.5	15	34.5	1	1	2
2	Standard diet	34	25	59	2	2	4
3	Standard diet	22.5	22	44.5	3	3	6
4	Standard diet.	24	21	45	1	1	2
	September 23						
1	One bird released; the other post-mortemed	22	18	40	2.5	3	5.5
2	One bird released; the other post-mortemed	36	27.5	63.5	2	2.5	4.5
3	Both birds released	24	23	47	1.5	1	2.5
4	Both birds released	25.5	21	46.5	1.5	0	1.5

* The "standard diet" consisted of *Gold Medal Turkey Builder* and *Gold Medal Developing Grain*. Water was available at all times and finely crushed limestone was kept before all birds after August 30. Weight changes listed indicate gain or loss during preceding period.

the weight loss was again due in part to lack of nourishment. Satisfactory gains were recorded after the birds were put back on the standard diet on September 11.

Pair 4 consisted of small birds, and from August 9 to August 23, these were fed the standard diet, liberally admixed with U.S.D.A. standard bait. They did not take readily to this combination, and is that these young pheasants survived comparatively large doses of arsenic in the form of poison baits and poisoned grasshoppers, and apparently entirely overcame any resultant ill effects.

The two birds upon which autopsies were performed failed to reveal evidence of gross pathological changes of any kind. The only blemish found in either was a bruised leg muscle that had obviously

Table 2.—Results of chemical analyses to determine amount of arsenic retained in tissues of two experimental pheasants.

	Bird from Pair 1			Bird from Pair 2		
		As_2O_3			As_2O_3	
Sample	Weight*	Total in mmg.	Parts per million	Weight	Total in mmg.	Parts per million
Gizzard lining and contents	9.5	0	0	10.4	0	0
Gizzard	13.7	9.0	0.66	14.65	13.5	0.92
Ingluvies and contents	3.1	0.98	0.32	3.3	0	0
Intestines and contents	29.0	7.74	0.27	23.0	7.02	0.31
Caeca	8.0	7.02	0.88	7.2	3.96	0.55
Liver and gall bladder	20.0	1.44	0.07	22.0	2.52	0.11
Kidneys	4.6	0	0	5.2	0.98	0.19
Heart	3.65	1.70	0.47	6.0	2.96	0.49
Blood	10. ±	13.22(?)	1.32(?)	10. ±	0	0
Breast meat	83.0	7.83	0.09	107.2	9.44	0.09
Breast bone	8.2	1.44	0.18	10.5	4.22	0.40
Leg meat	49.5	4.94	0.10	59.0	3.96	0.07
Leg bones	9.0	0	0	9.0	2.24	0.25
Droppings†	2.3	155.84	67.75 (ave. = 3.9 mmg. each)	2.6	317.45	122.10
Fifty poisoned grasshoppers	?	195.0				
Standard diet	10.0	4.22	0.42			
Blank	—	0.49	—			

* Weight records of body parts are grams of wet weight. Those of droppings and feed are grams of air-dried samples.
† Droppings from pair 1 were collected on September 13, when most of the droppings were of a purplish-red color. Those of pair 2 were dropped about September 6 and were partly green in color.

this is reflected in the comparatively small weight gains. During the subsequent seven day period they were fed only the standard diet in their feed dish, but a handful of the bait was scattered over the cage floor each day. The rate of gain increased during this interval, and continued satisfactorily after August 30 when they were put on the standard diet exclusively.

Two points warrant emphasis at this time. First is the fact that all birds showed a distinct dislike for the poison baits, and apparently fed on them little or not at all unless prompted by hunger. This confirms several observations by different writers (Zimmerman, 1938). The same does not hold true for grasshoppers killed with arsenical baits, since these were eaten almost as readily as were unpoisoned live hoppers. The second point resulted from a mechanical injury.

Data presented in table 2 show that the arsenic ingested with the feed was largely eliminated by these birds within a comparatively short time. The bird from pair 1 was killed only 7 days after the end of the 20 day period during which the pair consumed 5,190 poisoned grasshoppers, while the representative of pair 2 was posted 23 days after the end of the 4 day period during which it was fed nothing except poison bait. Duplicated analyses of cage-poisoned insects showed 3.9 micrograms of As_2O_3 per grasshopper. The figures show that there was no significant retention or storage of arsenic in any of the organs or tissues of these birds. Tests of two samples of droppings confirm the hypothesis that the birds rapidly eliminated the arsenic in the feces, which is in accord with data presented by

Wilson and Holmes (1936). Apparently there is no hazard whatever in eating pheasants that have been through a grasshopper poisoning campaign.

SUMMARY.—Young pheasants in nature are apparently not menaced directly by arsenical baits as they are commonly recommended and used. Not only are the baits spread too thinly to make them readily available but even the better ones are decidedly unpalatable to the birds.

Caged pheasants consumed grasshoppers dead and dying as a result of eating arsenical baits almost as readily as they did unpoisoned grasshoppers, and there are no indications that they will not do so in nature.

A young pheasant that had eaten comparatively large quantities of the U.S. D.A. standard bait and another one fed exclusively on poisoned grasshoppers for a period of 12 days showed no gross pathological symptoms when autopsied, and neither of them retained significant quantities of arsenic in the body tissues subsequently analyzed.

The results presented here indicate that grasshopper poisoning campaigns are not an important menace to young ringneck pheasant or to individuals who may eventually consume birds so exposed.[2] —1-6-40.

[2] The following groups and individuals have contributed to the progress of this work: Professor Aldo Leopold; Wisconsin Conservation Department; Doctor Paul C. Bennett, Wisconsin Department of Agriculture and Markets; Mr. John LaPlant and Mr. M. H. Bingham.

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Effect of Fruit Growth and Weather on Deposits of Insecticides on Apples in Southern Indiana

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The chemical study of spray deposits to determine the loss of residue due to growth and weathering was first reported by Hamilton & Smith (1925) when they devised a method for determining the quantity and distribution of lead arsenate spray residues on fruit. R. H. Smith (1928) reported the investigation of arsenical spray residues and showed the relationship of growth and weathering to harvest residue deposits. Since 1928, investigators have generally included spray residue analyses in reports of the use of insecticides for codling moth control, but few have attempted to show the effect of growth or weathering on reduction of residue deposits. Hamilton (1929), Lathrop & Sazama (1932), Carter & Newcomer (1933), Hodgkiss *et al.* (1934), and Frear & Worthley (1937) have reported studies of lead arsenate spray deposits in which the loss of residue due to growth or weathering, or both, was discussed. Experiments conducted at the Vincennes station of the Bureau of Entomology and Plant Quarantine from 1935 through 1938 were so designed as to permit the separation of the decrease of residue concentration due to growth from that due to weathering. The experiments included studies of the rate of growth of six varieties of apples and the effect of weather on lead arsenate, nicotine bentonite, and phenothiazine spray residues.

Fruit growth reduces the concentration of insecticide deposit by expansion of the fruit surface and is therefore equally effective on all types of spray deposits but differs according to the variety of fruit. Loss by weathering, on the other hand, is relatively independent of varietal differences of fruit but affects spray deposits of various insecticides and spray mixtures differently. It is the purpose of this paper to discuss the effect of fruit growth and weather on spray residue deposits result-

ing from the application of insecticides for the control of the codling moth in apples.

METHODS.—Spray plots employed in the study of insecticides during 1935 and 1938 were in a block of Grimes Golden trees of moderate to good vigor. The trees were from 15 to 20 feet high with a spread of approximately 20 feet. Plots in a similar block of Jonathan trees were employed during 1936 and 1937. Fruits for growth studies were taken both from the trees used for insecticide studies and from trees of approximately the same age and growing condition located in orchards nearby. Samples for growth studies included Yellow Transparent, Turley, Golden Delicious, and Winesap as well as Grimes and Jonathan.

Fruit samples were taken from two trees in each plot and from three horizontal sections of the trees according to the normal crop distribution on the tree. The samples for chemical analysis consisted of 50 fruits and were taken before and after each spray application and at harvest. Samples for growth studies, consisting of 100 to 500 fruits, were taken at the time of each spray application.

The spray schedules of the plots studied during the 4-year period are as follows:

1935

Lead arsenate: Lead arsenate 4 pounds, lime 1.5 pounds, and copper sulfate 0.75 pound to 100 gallons in three cover sprays. The dosage of lead arsenate was reduced to 3 pounds per 100 gallons in four additional cover sprays.

1936

Lead arsenate: lead arsenate 3 pounds, lime 1.5 pounds, and copper sulfate 0.75 pounds to 100 gallons in eight cover sprays.

Nicotine bentonite: Nicotine sulfate (40 per cent nicotine) 1 pint, bentonite 5 pounds, soybean oil 1 quart, and sodium lauryl sulfate 0.25 ounce to 100 gallons in four cover sprays. The nicotine sulfate and bentonite dosage was halved in four additional cover sprays.

1937

Lead arsenate without adhesive: Lead arsenate 4 pounds, lime 1.5 pounds, and copper sulfate 0.75 pound to 100 gallons in two cover sprays. The dosage of lead arsenate was reduced to 3 pounds to 100 gallons in five additional cover sprays.

Lead arsenate with adhesive: Lead arsenate 4 pounds and lime 4 pounds to 100 gallons in one cover spray. Lead arsenate 4 pounds, lime 1.5 pounds, copper sulfate 0.75 pound, soybean flour 0.25 pound to 100 gallons in one cover spray. Lead arsenate 4 pounds, lime 1.5 pounds, copper sulfate 0.75 pound, and mineral oil 2 quarts to 100 gallons in one cover spray. Lead arsenate 3 pounds, lime 1.5 pounds, copper sulfate 0.75 pound, and mineral oil 2 quarts to 100 gallons in one cover spray. The last mentioned formula without mineral oil was used in four additional cover sprays.

Tank-mix nicotine bentonite: Nicotine sulfate (40 per cent nicotine) 1 pint, bentonite 5 pounds, soybean oil 1 quart, and sodium lauryl sulfate 0.5 ounce to 100 gallons in four cover sprays. The dosage of nicotine sulfate and bentonite was halved in three additional cover sprays.

Factory-processed nicotine-bentonite: Factory-processed nicotine-bentonite (5 per cent nicotine) 6 pounds and mineral oil 1 quart to 100 gallons in two cover sprays. The dosage of mineral oil was doubled in five additional cover sprays.

Phenothiazine without adhesive: Phenothiazine 4 pounds to 100 gallons in seven cover sprays.

Phenothiazine with adhesive: Phenothiazine 4 pounds and soap 2 pounds (precipitated with calcium chloride) to 100 gallons in four cover sprays. The dosage of soap was reduced to 1 pound in three additional cover sprays.

1938

Lead arsenate: Lead arsenate 4 pounds, lime 4 pounds, and soybean flour 0.25 pound to 100 gallons in one cover spray. Lime 1.5 pounds, copper sulfate 0.75 pound, and mineral oil 2 quarts to 10 gallons plus 4 pounds lead arsenate in one cover spray and plus 3 pounds of lead arsenate in one cover spray. Lead arsenate 3 pounds, lime 1.5 pounds, and copper sulfate 0.75 pound to 100 gallons in five additional cover sprays.

Nicotine bentonite: Nicotine sulfate (40 per cent nicotine) 1 pint, bentonite 5 pounds, soybean oil 1 quart, and sodium lauryl sulfate 0.5 ounce to 100 gallons in four cover sprays. The dosage of nicotine sulfate and bentonite was reduced one-third in four additional cover sprays.

Phenothiazine: Phenothiazine 4 pounds to 100 gallons in eight cover sprays.

In determining the surface area of samples used in these studies the method outlined by Carter & Newcomer (1933) was employed. These authors discuss several methods of obtaining the surface area of apples and conclude that the error introduced by the assumption that the apple is a sphere of uniform density is not greater than 3 per cent. When apples were submerged in water it was found that they displaced 1.2 cubic centimeters per gram of weight and that this relationship did not vary greatly with variety or during the season. The surface area was therefore calculated by the following formula: Surface area $= 4.84\,[\sqrt[3]{(\text{weight} \times 1.2)}]^2$.

Lead arsenate spray deposits were analyzed for arsenic by the method of arsenic trichloride distillation and bromate titration (Jones 1934). In 1936 and 1937 nicotine deposits were determined by stripping the nicotine residue from the fruit, isolating it by steam distillation, and then applying the silicotungstic acid method

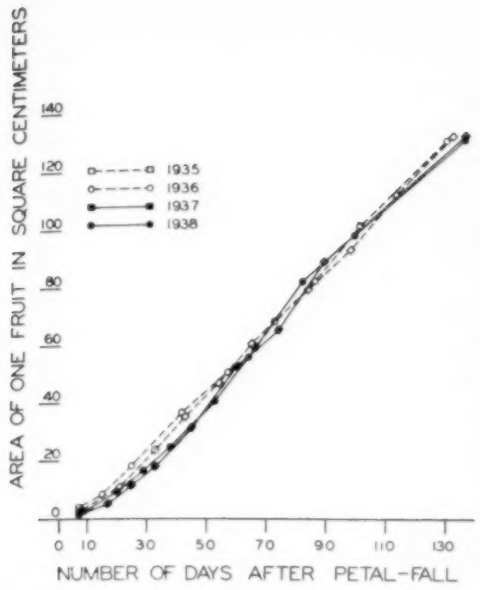

FIG. 1.—Rate of growth of Grimes Golden apples in 1935, 1936, 1937, and 1938 at Vincennes, Ind.

(Association of Official Agricultural Chemists, 1930). In 1938 nicotine deposits were analyzed by the photometric method, devised by Markwood (1939). Phenothiazine residues were determined by a method developed by Murray, of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture (unpublished), and independently by Eddy & DeEds (1937), which consists of stripping the residue from the fruit with hot alcohol, treating the solution thus obtained with bromine, and comparing the color developed to colors produced by known quantities of phenothiazine. All residues are reported in milligrams of arsenic trioxide, nicotine, or phenothiazine per fruit in order that the factor of fruit growth may be separated from that of weathering. The methods of analysis used in determining arsenic and nicotine residues are both highly accurate and precise. Although the same may be said of the method for phenothiazine when applied to the analysis of the pure material, the accuracy of the method when applied to the analysis of spray residues may be considerably lowered by the behavior of decomposition products that exist in the residues.

FRUIT GROWTH.—Since fruit development is a natural function of the tree, it was anticipated that weather conditions would control the rate of growth of apples. Growth studies were made of Grimes Golden apples in one orchard for a period of 4 years.

Figure 1 shows the average area of individual fruits from petal-fall until harvest. Although four growth curves have been plotted, the data could very well have been used to establish a composite curve. The only difference which could be attributed to seasons was that of data of petal-fall, which ranged from April 20 in 1938 to May 6 in 1937. The monthly precipitation records for the four growing seasons shown in table 1 indicate a wide difference in growing conditions.

Table 1.—Precipitation records during the growing season, 1935–38, Vincennes, Ind.

MONTH	PRECIPITATION IN INCHES			
	1935	1936	1937	1938
May	7.40	.99	3.02	5.56
June	6.32	1.72	4.48	5.53
July	2.25	3.47	.86	6.48
August	5.19	1.92	2.14	4.68
September 1–15	.74	.81	3.70	2.02
Total	21.90	8.91	14.20	24.27
Average Daily	.15	.06	.10	.17

Growth records for 1937 of six varieties of apples are shown in figure 2. As would

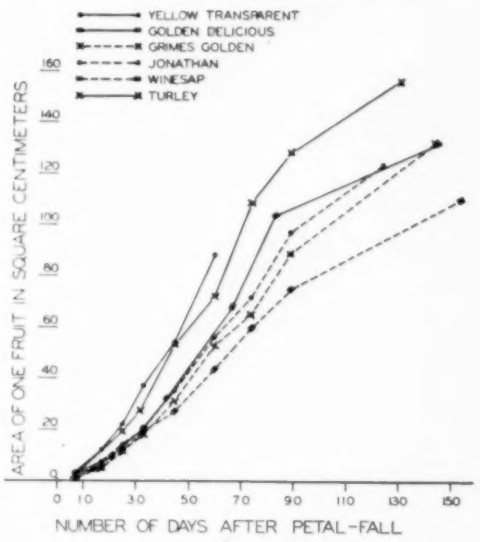

FIG. 2.—Rate of growth of six varieties of apples during 1937, Vincennes, Ind.

be expected, there is great variation in the growth curves of the several varieties. Yellow Transparent apples harvested early in July showed the most rapid growth. Turley apples were second and attained the largest size. Golden Delicious, Jonathan, and Grimes followed Turley in the order named. Winesap, the smallest fruit studied, showed the lowest rate of growth.

From the data presented it is apparent that seasonal differences in the rate of growth of individual varieties are not great. On the other hand, the rate of growth of varieties is definitely related to the average size of the harvested fruit and to the date of maturity.

In table 2 data are presented to demonstrate the effect of fruit growth on spray residue deposits. The period from petal-fall to harvest approximates 130 days, during which time the fruit attains an average surface area of about 130 square centimeters. Thus the average increase approximates 1 square centimeter per day. The actual increase as obtained from measurements taken at 10-day intervals (Table 2) ranges from 0.4 square centimeter to 1.2 square centimeters per day. The per cent increase in area is greatest during the first 10 days of the growing season and drops during each succeeding 10-day period.

The reduction in concentration of residue deposit caused by growth is a function of the area of the fruit and the per cent increase in surface area. Thus when the area increased from 4 square centimeters to 10 square centimeters (150 per cent) in 10 days the residue concentration was decreased 60 per cent. During the early part of the season growth causes the greatest reduction in residue concentration. Burkholder & Lehker (1939) point out that the interval between sprayings should be shortened during the early part of the growing season to compensate for the rapid expansion of the fruit surface.

Table 2.—Increase in surface area of Grimes Golden fruit due to growth and its effect on residue deposit, Vincennes, Ind.

Days After Petal-Fall	Area of One Fruit, Square Centimeters	Increase During Period	Reduction in Concentration of Deposit
0	0.0	—	—
10	4.0	—	—
20	10.0	150.0%	60.0%
30	19.0	90.0	47.4
40	29.0	52.6	34.5
50	41.0	41.4	29.3
60	52.0	26.8	21.2
70	64.0	23.1	18.8
80	76.0	18.8	15.8
90	87.5	15.1	13.2
100	98.0	12.0	10.7
110	109.0	11.2	10.1
120	119.0	9.2	8.4
130	128.0	7.6	7.0

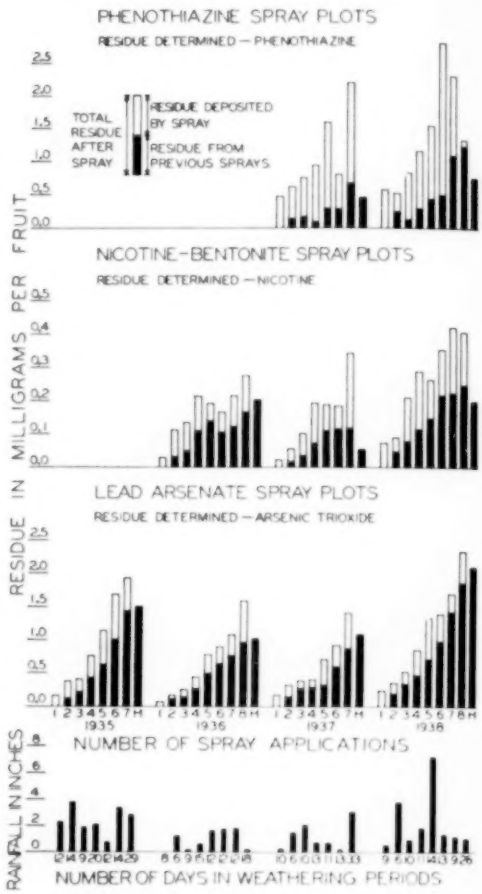

FIG. 3.—The effect of weather on lead arsenate, fixed nicotine, and phenothiazine spray residue deposits during 1935, 1936, 1937, and 1938.

WEATHERING OF RESIDUES.—The effect of weather in reducing residue deposit has been studied with lead arsenate, fixed nicotine, and phenothiazine spray mixtures. The studies with lead arsenate covered 4 years, those with fixed nicotine 3 years, and those with phenothiazine 2 years.

The results of these studies are pre-

sented in figure 3, together with the precipitation record. The residue deposits are reported in milligrams per fruit to eliminate the factor of loss in concentration due to growth.

In the data for lead arsenate it will be noted that there is a consistent tendency to accumulate residue load. At no time does the residue load drop below that from previous sprays, and the residue load at harvest is greater than that before the last spray application. The harvest residue load in 1935, 1936, and 1937 was 55.6, 51.5, and 57.8 per cent, respectively, of the total residue deposited during the growing season. In 1938, when mineral oil was used in two spray applications, the harvest residue load was 76.1 per cent of the total residue.

Little evidence was found to indicate that lead arsenate residues are removed from the fruit surface by rains. These results are in agreement with those of Frear & Worthley (1937) and Shaw & Steer (1939). It is apparent that fruit growth is far more important than weathering in the reduction of the concentration of residue deposits from lead arsenate sprays.

The residue deposits from fixed nicotine sprays show somewhat the same tendency to accumulate. The residue loss between sprays, however, is greater than with lead arsenate and in 2 of the 3 years of study the harvest residue was less that that on the fruit prior to the last spray application. In 1936 only 18 days elapsed between the final cover spray and harvest and the accumulated rainfall amounted to 0.19 inch. As a result 32.6 per cent of all residue deposited during the season was retained at harvest. In 1937, when 33 days elapsed between the final cover spray and harvest and the rainfall amounted to 3.06 inches, only 8.4 per cent of the total residue was retained. In 1938, when 26 days elapsed between the final cover spray and the rainfall amounted to 1.3 inches, 19.2 per cent of the total residue was retained.

The data for phenothiazine show the extreme in susceptibility of residues to weathering. In 1937 there was very little indication of residue accumulation, when only 7.9 per cent of all residue deposited was retained at harvest. In 1938 the condition improved somewhat but even then only 9.8 per cent of the total residue was retained.

It is evident from figure 3 that lead arsenate possesses greater resistance to weathering than either fixed nicotine or phenothiazine, and that the fixed nicotine mixture is more resistant to weathering than is phenothiazine.

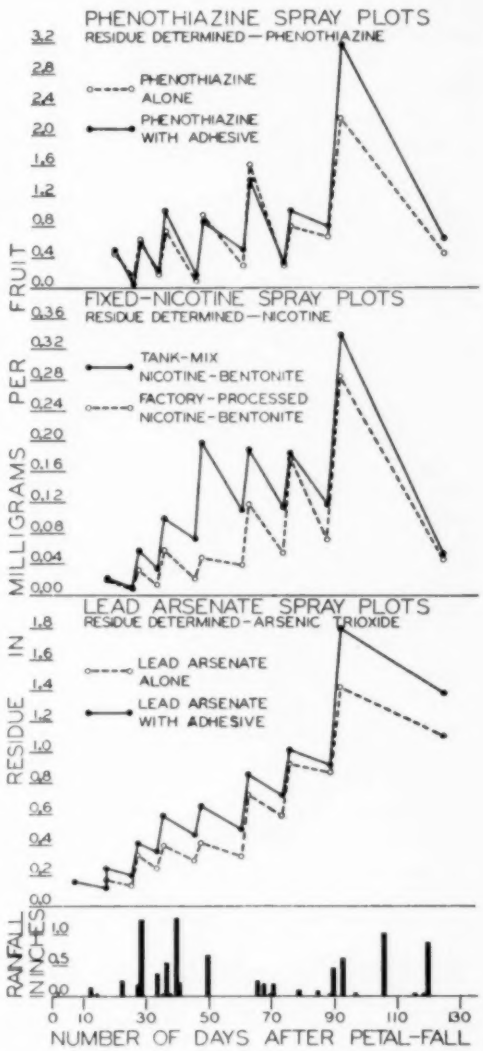

FIG. 4.—The effect of weather on spray residues from lead arsenate, fixed nicotine, and phenothiazine insecticides used alone and in combination with adhesives.

In 1937 two spray treatments were studied with each of the insecticides. Lead arsenate and phenothiazine were used alone and with adhesives and two types of fixed nicotines were studied.

The data from these studies are shown

in figure 4, with the precipitation record.

The data for lead arsenate show that a definite advantage was gained by the extra spray application and by the addition of adhesive. If one considers the percentage of the total residue that is retained at harvest, there appears to be little need for the adhesive because the plot without adhesive retained 2.7 per cent more of the total residue than the plot with adhesive. This does not necessarily indicate a failure of the adhesive but rather demonstrates the excellent adhesive qualities of lead arsenate itself.

The two types of nicotine deposits show a very definite relationship to the quantity of nicotine contained in the spray mixture. During the period of the first four cover sprays the tank-mix nicotine bentonite shows a definite advantage over the factory-processed material. During the latter half of the growing season it loses this advantage and both plots have approximately the same final residue load at harvest. Similarly both plots show practically the same percentage of the total reisdue deposit retained at harvest.

The difference between the two phenothiazine plots is not consistent and it is questionable if any of the differences shown are significant. This further demonstrates the susceptibility of phenothiazine residues to weathering. The adhesive added to the phenothiazine caused an increased percentage of the total residue deposited to be retained at harvest; however, in both plots the quantity was less than 10 per cent.

SUMMARY.—Investigations were carried on in southern Indiana during the period 1935–38 to determine the effect of fruit growth and weathering on spray residue deposits on apples. The insecticide studies were conducted in a block of Grimes trees in 1935 and 1938 and in a block of Jonathan trees in 1936 and 1937. Fruit samples for chemical analysis were taken from three horizontal sections of the trees according to the normal crop distribution on the tree. They were taken before and after each spray application and at harvest. Samples for fruit-growth studies were taken from the same trees used for insecticide studies and from other trees located in the vicinity. They were taken at the time of each spray application and were selected as for insecticide studies. The insecticide treatments consisted of various sprays of lead arsenate, fixed nicotine, and phenothiazine.

Growth records of Grimes Golden apples for 4 consecutive years and of several varieties of apples for 1 year showed that growth rate differed according to variety of fruit but only to a slight extent according to seasonal conditions.

Fixed nicotine was found to be less susceptible to weathering than phenothiazine, and lead arsenate was the least susceptible of the three insecticides. Fruit sprayed with lead arsenate retained at harvest from 51.5 to 76.1 per cent of the total residue deposited during the season. Fruit sprayed with fixed nicotine retained from 8.4 to 32.6 per cent of the total residue, depending on the interval between the final cover spray and harvest and on the rainfall.—1-20-40.

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Toxicity of Nicotine Administered Internally to Several Species of Insects

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The manner in which fixed nicotines act against newly hatched codling moth larvae is not precisely known. If the action is primarily through the digestive system, as some workers believe, it becomes useful to know something of the action of fixed and free nicotines administered in this way against larger insects where doses can be measured accurately.

Not many workers have reported experimental evidence that nicotine can act primarily as a stomach poison. It was commonly stated 25 years ago that nicotine acted not only as a contact, but also as a stomach poison against several lepidopterous larvae (Capus & Feytaud (1909), Marchal (1912), Fixmer (1913). These workers speak of the efficiency of nicotine bordeaux sprays against *Clysia ambiguella* Hb. and *Polychrosis botrana* Schiff. Schwartz (1913) killed larvae of *Vanessa polychloros* L., *Vanessa io* L. and *Notolophus antiqua* (L.) with 0.05 per cent solutions, *Lymantria dispar* L. and *Stilnotia salicis* L. with 0.2 per cent solutions and *Malacosoma neustria* L. with 1 per cent solutions. These solutions were sprayed onto foliage upon which the test larvae fed. McIndoo (1916) fed honeybees (*Apis mellifera* L.) 1 per cent alkaloid in honey and killed all insects which fed. He attempted to trace the nicotine through the walls of the honey stomach and into the blood and ganglia by means of staining reactions. Stellwaag (1929) stated that nicotine might act as a stomach poison against the vine moth. Yabuta & Kozu (1931, 1932) found that mulberry leaves growing adjacent to tobacco might contain one part nicotine in 100,000 and be toxic to silkworm larvae (*Bombyx mori* L.)

There are records of still fewer attempts to assign a lethal dose to the action of nicotine either as a stomach or a contact poison. Walker & Miller (1927) estimated, on the basis of concentration and volume of air used, that 0.00075 mg. of nicotine was needed to kill a boll weevil (*Anthonomus grandis* Boh.) by fumigation. If we estimate the weight of a weevil as 0.04 gm., this figure would reduce to .019 mg./gm. Campbell (1932) estimated the lethal dose for silkworms by injection into the blood stream to be .0015 mg./gm .Working with *Celerio lineata* Fab. Hockenyos & Lilly (1932) did not estimate a dose in terms of milligrams per gram, but give data that make it possible to estimate this dose as between .2 and 1.0 mg./gm. of alkaloid administered as the sulphate in subcutaneous injection. Glover & Richardson (1936) found that the bodies of roaches (*Periplaneta americana* (L.)) had absorbed about 1.2 mg./gm. of nicotine from a fumigating vapor at the time of 50 per cent mortality. Simanton (1937) found the quantity of nicotine per gram of body weight necessary to kill *Aphis rumicis* L., *Blatella germanica* (L.) and *Lygaeus kalmii* Stål. by contact were respectively, .048, 2.15 and 3.2 at the point of 50 per cent mortality and .115, 3.2 and 6.8 at the point of 80 per cent mortality. The most complete data of this type is that of McIndoo (1937) who injected several species subcutaneously and reported his data in terms of number of milligrams of insect killed by one milligram of nicotine. Converted to milligrams of nicotine per gram of insect his figures are as follows: *Lucilia sericata* (Meig.) males, 0.37; females, 0.65 to 0.89; *Calliphora erythrocephala* (Meig.) males, 1.08; females, 1.09; Codling moth larvae, 0.85; silkworm larvae, 1.44; southern armyworm larvae, 1.98; *Phormia re-*

gina (Meig.) larvae, 3.31. It is to be noticed that the dose for the silkworm is 960 times that estimated by Campbell.

MATERIALS AND METHODS.—Samples of nicotine and its compounds were obtained from various outside sources and their analyses for alkaloid checked by Dr. Norton, or they were prepared directly by him. The compounds used in this investigation are described below.

Nicotine alkaloid. This material was purified from a commercial 95 per cent grade. According to the method of Ratz (1905), the nicotine was dissolved in alcohol and crystallized with zinc chloride. It was then separated from an aqueous solution with KOH and dehydrated with solid KOH. After distillation at 17 mm. pressure it was stored under nitrogen in a glass-stoppered bottle in the dark. This alkaloid is water-white and has a specific optical rotation of −168.90 degrees which indicates practically 100 per cent purity.

Nicotine caseinate was supplied by Colloidal Products Corporation of San Francisco. By analysis it was found to contain 20.64 per cent nicotine.

Nicotine peat. Doctor L. N. Markwood of the Division of Insecticide Investigation, Bureau of Entomology and Plant Quarantine furnished this material compounded with New Jersey peat. It contained 10.05 per cent of nicotine.

Nicotine stannous chloride (double salt). Prepared by Dr. Norton by the addition of $SnCl_2$ solution to concentrated nicotine containing an excess of HCl. It contained 25.13 per cent of nicotine. This crystalline salt probably exists only in the solid form. It, however, is the least soluble of a series of double salts prepared for these and other tests.

Nicotine Reineckate. Reinecke salt was prepared from ammonium thiocyanate and ammonium dichromate according to the method of Dakin (1935). The nicotine compound, which is insoluble, was precipitated from solution with either the alkaloid or the sulfate. It contains 31.75 per cent of nicotine.

Nicotine silicotungstate. This material also was prepared by Dr. Norton by the addition of 10 per cent silicotungstic acid to a solution of nicotine acidified with HCl. The washed and dried precipitate contained 10.12 per cent of nicotine.

Nicotine Aresket was furnished by Monsanto Chemical Company. It is apparently a compound of nicotine with an alkylphenylbenzene sulfonic acid. Contains 21.48 per cent of nicotine.

Nicotine 2–4 dinitro-6-cyclohexylphenate was furnished by the Dow Chemical Company and was found to contain 37.86 per cent of nicotine.

Methods of administering doses varied according to the insect used and the physical properties of the insecticide. Two modifications of the "sandwich method" of Campbell & Filmer (1929) were used. With powdered materials, leaf discs of the food plant were dusted in a bell-jar, the amount deposited being estimated from the gain in weight of a paper of ten times the area of a leaf disc. Over these dusted discs another disc lightly coated with starch paste was fitted. With liquid insecticides, a starch paste mixture of known concentration of nicotine was measured directly onto the leaf disc from a micro-syringe as described for use in the injection experiments. This drop of paste-nicotine was spread as evenly as possible over the surface of the disc with a second disc which became the other half of the sandwich. Areas eaten were measured under a binocular microscope by counting millimeter squares exposed when the partially eaten sandwich was placed on a circle the exact size of the sandwich drawn on millimeter-ruled paper.

A micro-syringe for injection was built by clamping a micrometer head capable of measuring one inch in thousandths so that the pin pushed the plunger of a Becton, Dickinson and Company 0.25 cc. Yale tuberculin syringe No. $\frac{1}{4}$ LT. The needles were of finely drawn glass tubing. These were cemented to Becton, Dickinson and Company Yale hypodermic needles No. LNR, $\frac{1}{2}$ inch, 27 gauge. Particularly with the hypodermic injections of smaller larvae the glass needles, of approximately 0.004 inch outside diameter, gave little trouble from blood loss, whereas the 27 gauge steel needles of 0.016 inch outside diameter did cause considerable loss of blood. With the exception of the glass needle, the apparatus was similar to that used by Trevan (1922). The syringe assembly was clamped rigidly in place with the needle focussed under a binocular microscope and the insect moved onto the needle by hand. The latter was calibrated and found to deliver 0.000194 cc. of liquid for every 0.001 inch movement of the

plunger. Gut injections were made through the mouth into the pharynx and blood injections into the left front proleg with the needle directed cephalad.

SANDWICH TESTS.—Table 1 gives a summary of the data on toxicity of nicotine compounds fed to various insects in leaf sandwiches. It is felt that with the double leaf sandwiches the materials have little opportunity to act as contact insecticides except through the gut wall. It will be noted that compounds of several types were used. They may be roughly grouped into insoluble compounds such as the silicotungstate, Reineckate, and peat, compounds in which the material combined with nicotine might be expected to be toxic (Reineckate and 2–4 dinitro-6-cyclohexylphenate), soluble compounds with wetting or spreading properties (*Aresket* and caseinate) and soluble compounds with none of the above properties (nicotine alkaloid and the stannous chloride double salt).

Although check insects were fed sandwiches containing only starch paste, paralleling these tests, they are not listed in the table because of the complete lack of mortality.

Susceptibility or resistance to poisoning by nicotine administered through the digestive system seems to be more closely related to the species of insect than to the chemical or physical properties of the insecticide. Naturally this applies mainly to laboratory work where weathering of spray deposits and compatibility with other substances is not a problem. The silkworm is about equally susceptible to soluble and insoluble materials, the median lethal dose of the alkaloid being about 0.01 mg./gm. whether pure or as the silicotungstate or Reineckate. Other insects tested were, with few exceptions, able to survive any dose it was possible to feed them.

One of the most interesting features of the investigation was the unique high

Table 1.—Toxicity of nicotine fed in leaf sandwiches.

INSECT—4TH AND 5TH INSTAR LARVAE UNLESS OTHERWISE NOTED	INSECTICIDE	NO. INSECTS	MEAN WEIGHT GMS.	RANGE OF DOSES MG./GM.	SMALLEST LETHAL DOSE MG./GM.	LARGEST NON-LETHAL DOSE MG./GM.	MORTALITY
Malacosoma americana (F.)	Nicotine alkaloid	73	.290	.0006– .414	—	.414	0
Hyphantria cunea (Drury)	Nicotine alkaloid	23	.226	.01 –1.02	—	1.02	0
Lycophotia margaritosa saucia Hbn.	Nicotine alkaloid	40	.545	.05 –2.07	—	2.07	0
Mamestra picta Harr.	Nicotine alkaloid	12	.737	.070 – .56	—	.46	0
Estigmene acraea (Drury)	Nicotine alkaloid	17	.881	.12 – .46	—	.56	0
Halisidota caryae (Harr.)	Nicotine alkaloid	25	.071	.007 – .16	—	.16	0
	Nicotine Reineckate	25	.075	.058 – .20	—	.20	0
Pro'aparce sexta (Johan.)	Nicotine alkaloid	6	.839	.96 –7.08	—	7.08	0
Protoparce quinquemaculata (Haw.)	Nicotine alkaloid	26	3.88	.03 –4.65	3.53	3.83	8
	Nicotine Reineckate	40		.018 – .27	.018	.17	65
Cacoecia cerasivorana (Fitch)	Nicotine alkaloid	103	.030	.0007– .054	—	.054	0
	Nicotine caseinate	15	.025	.005 – .049	—	.049	0
	Nicotine peat	44	.039	.020 – .186	—	.186	0
	Nicotine-$SnCl_2$ (double salt)	39	.039	.004 –1.02	—	1.02	0
	Nicotine Reineckate	19	.035	.009 – .079	—	.079	0
	Nicotine silicotungstate	12	.045	.005 – .034	—	.034	0
Leptinotarsa decemlineata (Say) adults	Nicotine alkaloid	84	.146	.01 – .57	—	.57	0
	Nicotine Reineckate	69	.159	.0006– .058	.004	.008	78
	Nicotine silicotungstate	52	.176	.061 – .057	—	.057	0
Leptinotarsa decemlineata (Say) larvae	Nicotine alkaloid	54	.083	.01 –1.01	—	1.01	0
	Nicotine Reineckate	119	.109	.001 – .068	.011	.068	13
	Nicotine silicotungstate	30	.107	.0055– .095	.0087	.095	7
Ascia rapae (L.)	Nicotine alkaloid	80	.121	.037 – .364	—	3.64	0
	Nicotine Reineckate	48	.133	.112 –1.78	—	1.78	0
	Nicotine Aresket	51	.111	.51 –9.80	—	9.80	0
	Nicotine 2–4 dinit o-6-cyclohexylphenate	62	.124	.003 – .72	.013	.72	28
Datana integerrima G. & R. 3rd instar	Nicotine alkaloid	25	.147	.014 – .14	.016	.095	56
Datana integerrima G. & R. 5th instar	Nicotine alkaloid	27	.332	.013 – .13	.013	.12	15
	Nicotine Reineckate	18	.335	.0442– .035	—	.035	0
Bombyx mori L.	Nicotine alkaloid	39	.130	.0010– .013	.0035	.013	59
	Nicotine silicotungstate	24	.104	.0023– .021	.010	.016	38
	Nicotine Reineckate	86	.094	.0112– .020	.0025	.017	30

toxicity of nicotine Reineckate to adult Colorado potato beetles. Not only was the median lethal dose low (estimated to be 0.004 mg./gm. on the basis of alkaloid) but the speed of action was surprising. Death generally occurred in two to six hours but the mortal effect of the poison was apparent within 15 minutes after feeding.

As discussed below, several insects showed reluctance to eat the nicotine sandwiches but fed freely on check sandwiches containing only paste. The imported cabbage worm and the tomato and tobacco worms, however, fed freely on nicotine alkaloid sandwiches, eating in some cases quantities of nicotine equal to 100 times the median lethal dose of lead arsenate. In no case with these three species was there any apparent physiological reaction to the poison. With the Reinecke salt against the tobacco worm there was considerable mortality, although the doses fed were much larger than those with the Colorado potato beetle adults. The imported cabbage worm ate doses of the Reineckate 10 times as large as the maximum non-lethal dose for the tobacco worm without being affected.

There is some evidence that third instar *Datana integerrima* larvae were more susceptible than fifth instar larvae.

With several insects nicotine was definitely repellent. These were *Cacoecia cerasivorana*, and *Halisidota caryae*. Two other larvae, *Euchaetias egle* (Drury) and *Nymphalis antiopa* L. were repelled to the extent that it was impossible to feed them measurable doses.

In another experiment an attempt was made to feed adult *Rhagoletis cingulata* (Loew) and *Rhagoletis fausta* O. S. with solutions containing 0.0156 to 10.0 milligrams of nicotine per gram of 10 per cent honey in water. Neither species would feed beyond an exploratory sip, although all test flies fed freely on similar honey solutions immediately after refusing those containing nicotine.

Small doses, in the above table, represent either repellence or a susceptibility to the insecticide which caused sickness before a large dose was eaten. There was ample evidence that this was the case with *Cacoecia*. For instance in one test begun with 50 insects only 9 had eaten measurable doses in an hour, while 22 more had begun to feed and stopped after eating less than 2 square millimeters of sandwich. Eighteen hours later 20 insects had eaten measurable doses, but 20 had eaten doses too small to measure. Although none of these larvae were killed with nicotine or any of its compounds they reacted more violently to the poison than any other species of insect tested, including the silkworm, which proved to be highly susceptible. Within 5 minutes of initiation of feeding the larvae showed signs of distress. The first stage was one of hypersensitivity and violent jerky movements. This was succeeded after about 5 minutes by a 1 to 4 hour period of tetanus with the body bent sharply backward. During this period excessive regurgitation occurred so that eventually the body seemed to have shrunk to half-size. Depending on the size of the dose taken, the next period lasted from a few hours to 3 days. This was a marked state of relaxation causing the insect to appear dead. When probed, however, the insect responded suddenly and violently. In every test these symptoms appeared, whether with the alkaloid or with compounds; high mortality was always expected, but complete recovery and a resumption of feeding invariably occurred.

This seems to be a clear-cut example of the paradoxical situation described by Dodonov (1936) and Voskresenskaya (1936) where insects resistant to arsenic (*Nygmia phaeorrhoea* Don., *Lymantria dispar* L. and *Euxoa segetum* Schiff.) were resistant only because of their extreme susceptibility which caused them to regurgitate and stop feeding before a lethal dose was ingested.

INJECTION TESTS.—In order to check the surprising lack of toxicity of nicotine to some of these insects, tests were made where the alkaloid was injected directly into the pharynx and the blood in measured volumes of solutions of known concentration. Although, in general, a uniform lack of toxicity was demonstrated in these tests, except with the silkworm, the difference in the two techniques should be emphasized. With leaf sandwiches the feeding period may last from a few minutes to several hours. Especially with the higher doses, where the insects feed for at least an hour, the dose arrives in the digestive tract in infinitesimal increments over a comparatively long period. Microchemical work on the distribution of nico-

Table 2.—Toxicity of nicotine alkaloid injected into pharynx and blood.

INSECT 4TH AND 5TH INSTAR LARVAE	NO. INSECTS	MEAN WEIGHT GMS.	CONCENTRATION OF NICOTINE PER CENT	DOSE MG./GM.	INJECTED INTO—	MORTALITY
Protoparce quinquemaculata (Haw.)	7	6.19	25.4	10.0	Pharynx	86
	8	7.42	10.0	5.0	Pharynx	100
	5	10.51	10.0	3.5	Pharynx	100
	14	9.21	10.0	2.0	Pharynx	29
	5	8.80	10.0	1.0	Pharynx	60
	10	9.32	Distilled water check		Pharynx	0
	5	7.24	10.0	2.5	Blood	60
	5	7.53	10.0	0.5	Blood	0
	5	10.28	10.0	0.1	Blood	0
	5	6.79	Distilled water check		Blood	0
Ascia rapae (L.)	14	.161	10.0	5.0	Blood	100
	10	.160	10.0	2.0	Blood	80
	10	.141	10.0	1.0	Blood	30
	6	.165	Distilled water check		Blood	0
Hyphantria cunea (Drury)	4	.225	1.0	2.5	Pharynx	0
	4	.100	1.0	1.0	Pharynx	0
	4	182	1.0	0.1	Pharynx	0
	4	.070	1.0	2.5	Blood	0
	4	.070	1.0	1.0	Blood	0
	4	.240	1.0	0.1	Blood	0
Carpocapsa pomonella L.	20	.042	1.0	1.0	Pharynx	0
	9	.043	1.0	0.1	Pharynx	0
	4	.063	Distilled water check		Pharynx	0
	10	.590	.1	.0040	Pharynx	100
	10	.596	.1	.0025	Pharynx	80
	10	.536	.1	.0020	Pharynx	40
	10	.421	.1	.0015	Pharynx	30
	10	.463	.1	.0040	Blood	100
	10	.413	.1	.0025	Blood	70
	10	.416	.1	.0015	Blood	30
Bombyx mori L.	5	.250	.01	.0025	Pharynx	20
	5	.251	.01	.0020	Pharynx	20
	5	.251	.01	.0015	Pharynx	20
	5	.280	.01	.0010	Pharynx	0
	5	.251	.01	.0005	Pharynx	0
	5	.412	.01	.0025	Blood	80
	5	.352	.01	.0020	Blood	40
	5	.392	.01	.0015	Blood	40
	5	.320	.01	.0010	Blood	20
	5	.310	.01	.0005	Blood	0

tine in the insect body, which will be published later, indicates that the dissemination of nicotine in the body is extremely rapid. This means that at no time during dosage will there be any marked concentration of alkaloid built up in any one locality. This is, of course, quite different from the situation obtaining where the full dose is injected almost instantaneously into the foregut or into the blood of the insects. Table 2 gives the data from this phase of the investigation.

It is obvious that little reliance can be placed on these injection data individually, because of the small number of observations. The data, as a whole, do indicate quite definitely that injected nicotine, like ingested nicotine, has several hundred times the toxicity to silkworms that it has to the other insects used. The silkworm data are closely in accord with Campbell's (1932) estimate of 0.0015 for a median lethal dose.

From the data in tables 1 and 2 it seems

that there is no highly significant difference in the toxicity of nicotine whether it is administered in leaf sandwiches, injected into the pharynx, or directly into the blood. This statement applies only very broadly, since there is some evidence that silkworms, imported cabbage worms and tobacco worms are killed more readily by injected nicotine than by that fed in sandwiches. The moderate toxicity of nicotine to imported cabbage worms and to tobacco worms seemed to have been due to the concentrated solutions used (10 per cent nicotine). The area where it was injected turned brown immediately and was apparently killed whereas the remainder of the insect was normal in color and continued to respond to stimuli for several hours. No discoloration of tissue was observed with 1 per cent concentration.

Another general conclusion was that some pronounced difference exists in the physiology of such resistant insects as the cabbage worm and the tobacco worm, and the highly susceptible silkworm. The degree of resistance shown by codling moth larvae which had developed almost to maturity in apples was surprising in view of the generally supposed susceptibility of newly hatched larvae. Swingle (1935) observed such a difference in susceptibility between newly hatched and more mature larvae of several species of *Lepidoptera* to fixed nicotine.

SUMMARY. Nicotine was administered in measured doses in two ways: by feeding leaf sandwiches containing known amounts of nicotine and measuring the areas eaten, and by injection of the nicotine directly into the blood or gut with a micro-syringe. Larvae which were not susceptible to nicotine were *Malacosoma americana* (F.), *Hyphantria cunea* (Drury), *Lycophotia margaritosa saucia* Hbn., *Mamestra picta* Harr., *Estigmene acraea* (Drury), *Halisidota caryae* (Harr.), *Carpocapsa pomonella* L., *Protoparce sexta* (Johan.), *Protoparce quinquemaculata* (Haw.), *Cacoecia cerasivorana* (Fitch), *Ascia rapae* (L.), *Datana integerrima* G. & R. and larvae and adults of *Leptinotarsa decemlineata* (Say). Contrasted to these resistant species which survived doses ranging from 0.04 to 9.8 milligrams nicotine per gram of body weight, *Bombyx mori* L. larvae survived no doses of nicotine above 0.0.017 mg./gm.

A compound of Reinecke's salt with nicotine was highly toxic to adults of the Colorado potato beetle and to larvae of the silkworm, moderately toxic to larvae of the tobacco worm, but not appreciably toxic to larvae of imported cabbage worm, hickory tussock moth, ugly-nest caterpillar, walnut caterpillar or to larvae of the Colorado potato beetle.

Euchaetias egle (Drury), *Nymphalis antiopa* L., *Cacoecia cerasivorana* (Fitch) and *Halisidota caryae* (Harr.) were repelled by nicotine in both soluble and insoluble forms. The first two species would not eat measurable doses, the ugly-nest caterpillar ate small amounts which, although they affected the larvae rapidly, were regurgitated before death occurred, and the hickory tussock moth larvae were not affected visibly by the small doses taken.

There seemed no highly significant difference in toxicity between the soluble and insoluble forms of nicotine or between ingested and injected nicotine. Third instar larvae of the walnut caterpillar were moderately susceptible to nicotine poisoning, whereas fifth instar larvae of the same species were not.—1-6-40.

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Introduction of Selenium into Plant Tissues as a Toxicant for Insects and Mites

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Coincident with the development of water culture in plant production the question has arisen whether a toxicant might be added to the nutrient solution as a means of control for phytophagous mites and insects.

Hurd-Karrer & Poos (1936) have shown that an aphid, *Rhopalosiphum prunifoliae* (Fitch), and red spider, *Tetranychus telarius* (L.), died within a few days when permitted to feed on 2-month-old wheat plants that were grown in a medium containing concentrations of selenium greater than 3 p.p.m.

Mason & Phillis (1937), in a preliminary investigation, obtained some evidence of selenium effectiveness against the cotton stainer and the pink bollworm on growing cotton.

On the other hand, Trelease & Trelease (1937) found that a species of bruchid, *Acanthoscelides fraterculus* (Horn), and a seed chalcid, *Bruchophagus* sp., completed their life cycles in air-dry seeds of *Astragalus bisulcatus* (A. Gray) which contained 1,360 p.p.m. of selenium.

Morris & Sayre of the Ohio Agricultural Experiment Station in a study of the physiology of growing corn had constant difficulty in rearing experimental corn plants to maturity in nutrient solutions in the greenhouse because of red spider injury. In the spring of 1937 they introduced selenium into the solutions as a corrective measure. The results were so gratifying that these investigators were soon using selenium regularly. A report of this work under the title "Toxicity of Selenium-containing Plants to Red Spider as a Means of Control" by Morris, Neiswander, and Sayre is being presented before the Section of Physiology at the present meeting of the American Association for the Advancement of Science.

During the fall of 1937 a more comprehensive selenium project was inaugurated at the Ohio Agricultural Experiment Station. The project was not confined to plants grown in solutions but was made to include those grown in soils as well.

The objectives were to determine the effect of selenium accumulations in plant tissues on infestations of mites and insects, the relative accumulations of selenium in the tissues of plants supplied with different levels of the material in nutrient solutions and in soils to be used as a supplementary criterion for evaluating pest response and the effect on plants of selenium accumulations in their tissues.

METHODS AND MATERIALS.—The nutrient solutions employed in these experiments had the following composition expressed as molecular concentrations: KH_2PO_4, 0.0053; KNO_3, 0.00798; $Ca(NO_3)_2$, 0.01086; $MgSO_4$, 0.00274; and $(NH_4)_2SO_4$, 0.00142. Iron, boron, manganese, and zinc were added as traces. The initial pH of the nutrient solution was adjusted with normal H_2SO_4 to approximately 5.5. In these solutions the concentrations of selenium, which was added as sodium selenate, varied from 0 to 2½ parts per million. In handling nutrient solutions containing selenium, rubber gloves were worn as a precaution against injury to the operator.

The plants were grown in 9-inch clay flowerpots filled with a mixture of one part fine sand and two parts 3/16-inch gravel. The sand and gravel were essentially pure silica. To facilitate drainage, a coarse gravel was used in the bottoms of the pots. The nutrient solution was supplied from mason jars by capillary glass tubing at the rate of 1 quart per day unless otherwise stated.

In some experiments 30 plants were used with 5 treatments and 6 replications, whereas in others there were 36 plants with 6 treatments and 6 replications. The experiments were arranged in blocks with the treatments distributed at random within the blocks.

In the one experiment in which soil cultures were used the selenium was mixed with the soil immediately before the plants were set. The selenium levels employed varied from 0 to 10 parts per million and were calculated on the basis of soil containing 20 per cent moisture. Selenium was added to the soil in the water used to bring the soil from the air-dry condition to 20 per cent moisture. Subsequent treatments consisted only of watering lightly as needed.

In both the soil and the water culture experiments all plants except roses were started in sand or compost. When several inches high, uniform individuals were selected for experimental purposes. In the case of roses, field-grown dormant plants of the variety Talisman were used. In order to secure uniform infestations of mites or insects all plants were artificially infested. This was done as soon as the plants had recovered from the shock of transplanting.

For the purpose of indicating the type of data taken, the values for all replicates are given for the first experiment. In the remainder of the experiments mean values only are presented. Statistical differences were determined by analysis of variance, and differences in means were considered significant at odds of 19 to 1.

Table 1.—Red spider population on tomato plants. January 4, 1938.

TREATMENTS	NUMBER OF LIVE MITES ON TWO LEAVES						
	R 1	R 2	R 3	R 4	R 5	R 6	Mean*
Check	139	395	96	167	94	112	167.2
Selenium ½ p.p.m.	71	90	20	40	23	72	52.7
Selenium 1 p.p.m.	29	3	1	0	3	1	6.2
Selenium 1½ p.p.m.	0	0	0	1	0	0	.2
Selenium 2 p.p.m.	0	0	3	0	0	1	.7

* A difference in means of 28.4 required for significance.

RED SPIDER ON TOMATO GROWN IN NUTRIENT SOLUTION.—This experiment was started November 10, 1937, when the plants were about 10 inches high. Three days later approximately equal numbers of the common red spider, *Tetranychus telarius* (L.), were placed on each plant. On December 2, three weeks after infestation, a population record was made by counting all mites on two sample leaves taken at random from each plant. It was found at that time that a high population of red spiders occurred on the plants in all treatments with only a slight diminution on the plants which had received the highest amount of selenium. Subsequent records and observations indicated that foliage which had developed before selenium was supplied to the plant did not contain as much selenium as did new tissue. All later population records were taken from leaves that had formed after the selenium-containing solutions were supplied to the plants.

Population records were taken again on January 4 and on January 21. The results from the two counts were practically identical. The January 4 record is shown in table 1.

It may be noted that as compared with the checks, the red spider population was reduced approximately 70 per cent on plants that received one-half p.p.m. of selenium; 96 per cent where 1 p.p.m. was used; and practically 100 per cent on the remainder of the series. These records are particularly significant because the plants of the several treatments were so close together that their leaves intermingled.

Growth records were taken throughout the season by measuring the height of all plants. It was found that the plants growing in the solution containing the highest rate of selenium were retarded in development as a result of selenium toxicity, whereas the check plants were retarded from red spider injury.

When the experiment was discontinued two lots of foliage consisting of three plants each were selected at random from each treatment for analysis. The results are given in table 2.

This table shows that as the concentration of selenium in the nutrient solution was increased there was a corresponding increase in the selenium content of the foliage. The authors are unable to explain the high selenium content in lot 1 of the control treatment. It is unfortunate that lot 2 of this treatment was lost.

Table 2.—Selenium concentration* in tomato foliage. Experiment 1.

TREATMENTS	SELENIUM (P.P.M.)		
	Lot 1	Lot 2	Mean
Check	39	—	39
Selenium ½ p.p.m.	64	51	57
Selenium 1 p.p.m.	130	112	121
Selenium 1½ p.p.m.	178	152	165
Selenium 2 p.p.m.	184	208	196

* The selenium analyses were made by Messrs. Wesley and Lawson Stoneburner under the direction of the junior author.

SECOND EXPERIMENT WITH RED SPIDER.—The results of the first experiment were so striking that a repetition of the work seemed advisable. Accordingly, a second series of tomato plants was started in sand cultures on February 5, 1938. The main difference between the two experiments was that the first crop was grown in midwinter and the second in the spring. The plants were treated in the same manner as in the preceding experiment except that as the plants approached maturity 2 quarts of solution were supplied to each plant daily instead of 1.

The mean data accumulated through the course of the experiment are shown in table 3.

The red spider population shown in table 3 was taken on June 24. It may be observed that there was a sharp decrease in population as the selenium content of the foliage increased. The plants grown in a solution containing as little as 1 p.p.m. of selenium were practically free of red spiders.

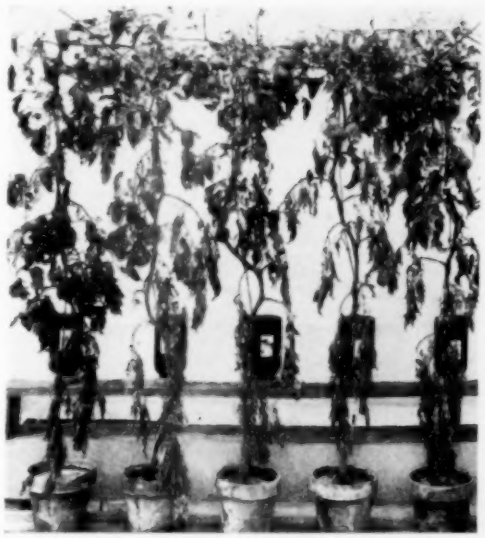

FIG. 1.—Plants of second tomato experiment that were grown in a solution to which no selenium was added. Serious red spider injury.

A slight toxicity to the plants grown in the solution with the highest selenium content was indicated by periodic growth measurements and also by the reduction in yield shown in table 3. A photograph of the check plants is shown in figure 1. It may be noted that much of the foliage is dead from red spider injury. The plants that were grown in a solution containing 2 p.p.m. of selenium are shown in figure 2. The abundance of luxuriant foliage, particularly on the lower part of the plants, should be noted.

Table 3.—Red spider population, selenium concentration in foliage, and yield of fruit from spring crop of tomatoes, 1938.

TREATMENTS	RED SPIDER POPULATION	SELENIUM IN FOLIAGE	YIELD OF FRUIT
	Mean of 6 Replicates*	Mean of 2 Replicates	Mean of 6 Replicates
Check	88	4 p.p.m.	76
Selenium ½ p.p.m.	18	87	80
Selenium 1 p.p.m.	1	98	75
Selenium 1½ p.p.m.	0	121	77
Selenium 2 p.p.m.	0	191	64

* A difference in means of 26.1 required for significance.

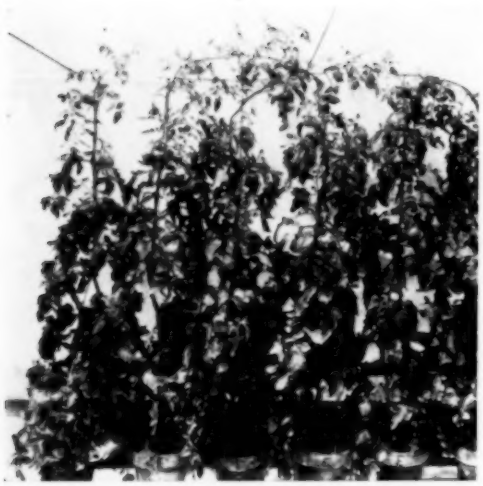

FIG. 2.—Plants of second tomato experiment that were grown in a solution that contained 2 p.p.m. of selenium. No red spider injury.

RED SPIDER ON STOCKS GROWN IN NUTRIENT SOLUTION.—An experiment with stock was started on February 10, 1938. Early in the course of the experiment the red spider infestation developed rapidly on all plants and seemed to be fairly uniform on all treatments. After 6 weeks, however, differences could be discerned by casual observation. A population record taken on April 20 and the selenium content of the plants taken at the close of the experiment are shown in table 4.

Table 4.—Red spider population and selenium concentration in foliage. Experiment with stocks, 1938.

TREATMENTS	RED SPIDER POPULATION	SELENIUM IN FOLIAGE
	Mean of 6 Replicates*	Mean of 2 Replicates
		p.p.m.
Check	341	1
Selenium ½ p.p.m.	292	21
Selenium 1 p.p.m.	261	55
Selenium 1½ p.p.m.	43	77
Selenium 2 p.p.m.	23	96

* A difference in means of 90 required for significance.

The highest selenium level used in this experiment did not result in complete elimination of the red spider infestation although the population was reduced 93 per cent from that on the check plants. Chemical analyses showed, however, that the selenium concentration in the foliage of stock was only about half as high as that in tomato foliage from corresponding treatments.

RED SPIDER ON ROSES GROWN IN NUTRIENT SOLUTION.—On November 18, 1938, an experiment was started on roses. The mites used for infestation purposes in this, as well as all other experiments reported here, were reared on potted bean and tomato plants grown in the entomology greenhouse. Roses had not been grown in this greenhouse for a number of years. This may be an important consideration, since it has been reported by Compton & Kearns (1937) that red spiders are harder to kill with insecticides on roses than on other plants.

Red spider injury to the foliage was apparent soon after the mites were placed on the plants. Within a short time defoliation occurred on the check plants and on those which were grown in the weaker concentrations of selenium. As a result, the mite populations on such plants were practically eliminated. When new foliage appeared it was some time before a destructive red spider population developed. It seemed, therefore, that population counts would not give a true interpretation of the effectiveness of the different treatments; hence they were not made.

On February 6, 1939, a little less than 3 months after the experiment was started, the plants of the different treatments were photographed. In figure 3 are shown the plants grown in a solution containing one-half p.p.m. of selenium. Much of the foliage from these plants may be seen lying on the pots. The remaining leaves were gray in color as a result of red spider injury. In figure 4 the plants that received 2½ p.p.m. of selenium are shown. The foliage of the plants in this group had a luxuriant green color and no leaves had been lost. In figure 5 one representative plant from each treatment is shown. It may be noted that there was a direct correlation between plant growth and the amount of selenium in the solution in which the plants were grown.

During the course of the experiment an individual production record was kept for each plant. The mean yield of flowers and the mean selenium content for the plants of each treatment are given in table 5.

In table 5 it is shown that there was a direct correlation between the number of

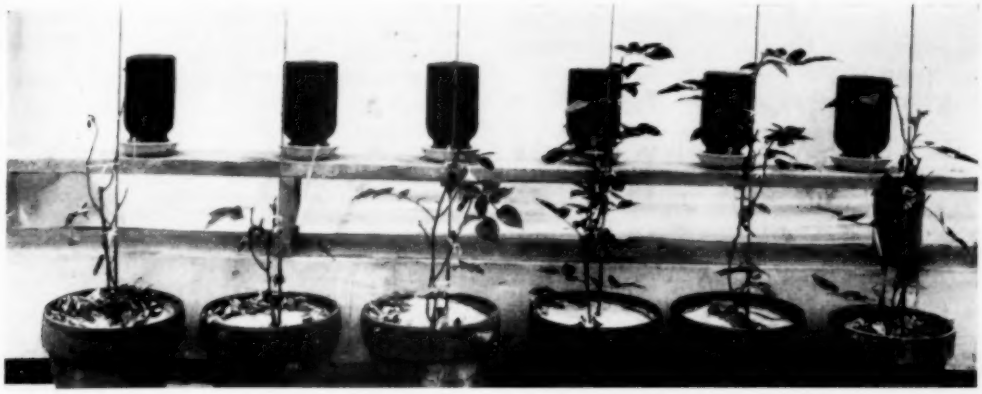

FIG. 3.—Rose plants that received ½ p.p.m. of selenium. Serious red spider injury.

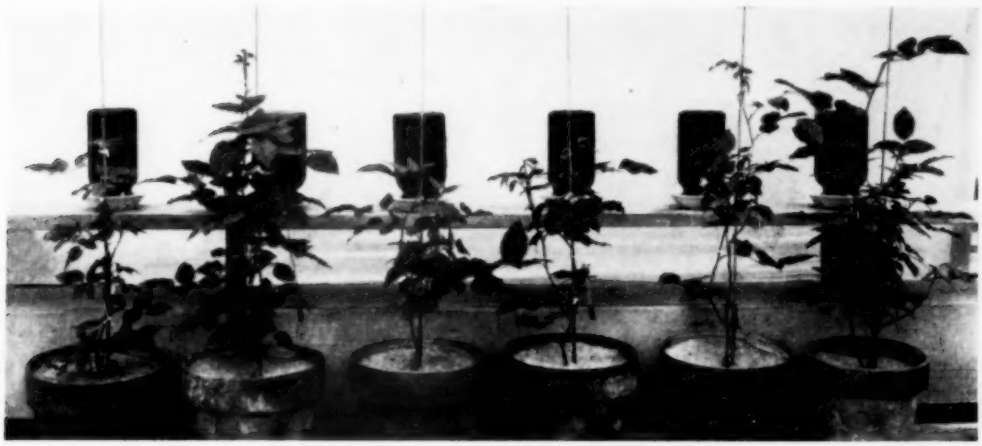

FIG. 4.—Rose plants that received 2 p.p.m. of selenium. No red spider injury.

FIG. 5.—A representative rose plant from each treatment. From left to right the plants received 0, ½, 1, 1½, 2, and 2½ p.p.m. of selenium respectively.

flowers produced and the concentration of selenium in the foliage. The amount of selenium stored in the foliage of roses, however, was much less than that in tomatoes or stocks.

Late in the spring a severe infestation of red spiders developed on the plants which had received the higher levels of selenium. The authors are unable to explain this change in behavior other than to suggest that the selenium concentration in the foliage may have decreased as the plants became older (Hurd-Karrer 1936) or that the later generations of mites may have become resistant to selenium at the concentrations that were present. Inasmuch as none of the plants showed any evidence of selenium toxicity, it is possible that a higher selenium concentration could have been established within the tissues of the plants without injury and might have served as a protection to the crop throughout the productive season.

Table 5.—Flower yield and selenium concentration in foliage. Rose experiment, 1939.

Treatments	Flowers Produced	Selenium in Foliage
	Mean of 6 Replicates*	Mean of 6 Replicates
Check	1.8	0 p.p.m.
Selenium ½ p.p.m.	2.8	8
Selenium 1 p.p.m.	6.7	13
Selenium 1½ p.p.m.	9.2	26
Selenium 2 p.p.m.	10.3	35
Selenium 2½ p.p.m.	10.8	45

* A difference in means of 3.6 required for significance.

RED SPIDER ON CARNATIONS GROWN IN NUTRIENT SOLUTION.—During the winter of 1938–1939 an experiment was conducted with red spider on carnations of the variety Delroy. Throughout the period of this experiment a general and severe infestation of red spider was present on the plants of all treatments. On April 14 a population count was made on four leaves taken at random from near the top of each plant. No difference was found other than the usual random variation. The analysis of the foliage for selenium concentration showed a maximum of 17.6 p.p.m. It may be assumed, therefore, that the failure to control red spider in this experiment was due to an insufficient amount of selenium in the foliage, particularly when it is recalled that the maximum selenium content in the foliage of rose, stock, and tomato was 45, 96, and 194 parts per million respectively.

Table 6.—Red spider population and selenium concentration in foliage. Carnations grown in selenized soil.

Treatments	Red Spider Population	Selenium in Foliage
	Mean of 5 Replicates*	Mean of 2 Replicates
Check	70	6 p.p.m.
Selenium 2 p.p.m.	33	23
Selenium 4 p.p.m.	10	28
Selenium 6 p.p.m.	0	69
Selenium 8 p.p.m.	1	75
Selenium 10 p.p.m.	0	115

* A difference in means of 27.2 required for significance.

RED SPIDER ON CARNATIONS GROWN IN SELENIZED SOIL.—Concurrently with the experiment on carnations of the variety Delroy grown in nutrient solution, another experiment was conducted with carnations of the variety Spicy White grown in selenized soil. The levels of selenium established in the soil were 0, 2, 4, 6, 8, and 10 parts per million. The plants were set November 23, 1938. Each treatment was replicated six times, but during the winter one plant of each of three treatments died from causes that did not apply to the experiment. As a consequence the sixth replicate of the other three treatments was dropped.

In no instance was toxicity to the plant observed from the levels of selenium used in this experiment. The only distinguishable difference between plants was the light color that occurred on the untreated check plants as a result of red spider injury.

On April 11, 1939, a red spider population record was obtained by examining four leaves from each plant and counting the live mites. The mean population values and the concentration of selenium in the foliage are given in table 6.

It is interesting to observe from this table that with 2 p.p.m. of selenium in the soil at the start of the experiment the red spider population on the foliage was reduced more than 50 per cent from that on the checks. With the selenium level

at 4 p.p.m. the population was reduced 85 per cent, and in all three treatments in which the selenium content in the soil was more than 4 p.p.m. the red spider infestation was practically eliminated. The plants of these three treatments had a mean selenium content in the foliage of the experiment indicated no significant differences other than those produced by aphid injury on the lower selenium levels.

Aphid population counts were made on May 16, 1938. The mean populations and the selenium concentrations in the foliage are shown in table 7.

FIG. 6.—Check chrysanthemum plants. No selenium. Two plants are dead from aphid injury and others are severely injured.

of 69, 75, and 115 parts per million respectively.

BLACK CHRYSANTHEMUM APHID ON CHRYSANTHEMUMS GROWN IN NUTRIENT SOLUTIONS.—During the winter of 1937–1938 a single experiment was conducted to ascertain the effect of selenium in plant tissues on populations of the black chrysanthemum aphid, *Macrosiphoniella sanborni* (Gillette). Chrysanthemum plants were transferred to solutions containing various levels of selenium on December 10, 1937. A few days later an aphid infestation was established on all plants in the series.

Throughout the early part of the winter, aphids were abundant on all plants, and for a time it appeared that there was little difference in aphid population. Later in the season, however, marked differences appeared. Growth records taken near the start and again near the close

The low significance for differences in means for the aphid populations given in table 7 undoubtedly resulted from a wide variation in values for the different replicates in the check treatment. This variation was at least partly due to the abandonment by aphids of some of the more

Table 7.—Aphid population and selenium concentration in foliage. Experiment with chrysanthemums grown in nutrient solution.

Treatments	Aphid Population	Selenium in Foliage
	Mean of 6 Replicates*	Mean of 2 Replicates
Check	24	1 p.p.m.
Selenium ½ p.p.m.	50	12
Selenium 1 p.p.m.	25	14
Selenium 1½ p.p.m.	3	25
Selenium 2 p.p.m.	1	45

* A difference in means of 36.7 required for significance.

severely injured plants previous to the time the population record was taken.

The highest selenium level contained in the foliage of the chrysanthemums was 45 p.p.m. The experiments with red spider on other hosts had indicated that this quantity of selenium in plant tissue was not sufficient to serve as an effective control for that organism. However, the scarcity of black chrysanthemum aphids on chrysanthemum plants which contained this quantity of selenium indicated that the concentration was adequate for the control of this insect. The effectiveness of the treatment is demonstrated also by a comparison of figure 6, which shows the untreated check plants, with figure 7, which shows the plants which were grown in a solution containing 2 p.p.m. of selenium.

FIG. 7.—Chrysanthemum plants that received 2 p.p.m. of selenium. Effective control of aphids.

DISCUSSION AND CONCLUSION.—The results of these studies have shown that when the selenium concentration of foliage approached 90 to 100 p.p.m. the red spider population was practically eliminated. In the one experiment conducted with the black chrysanthemum aphid similar results were obtained with a selenium content of 45 p.p.m. Even with half these quantities of selenium in the leaf tissues, significant reductions of both mites and insects resulted. Inasmuch as these experiments were conducted on artificially infested plants, it seems probable that under natural conditions still smaller amounts of selenium might prevent destructive populations from developing.

In the experiments in which the pests under consideration were not eliminated, comparatively small quantites of selenium were found in the foliage of the host plants. The concentration of selenium in the tissues of these plants probably could be increased by reducing the quantity of sulfate in the growth medium as shown by Hurd-Karrer (1935), or by increasing the concentration of selenium supplied to the plants through the growth medium.

Because of the known toxicity of selenium to higher animals, the question may be raised as to whether it can be handled safely by commercial growers of ornamental plants. Although it admittedly is a dangerous material to place in the hands of untrained men, the same certainly can be said of the better understood cyanides and arsenicals that now have a wide use.

Experimental results have demonstrated that selenium can be used effectively against some organisms. If by its use an animal as resistant to insecticides as is the red spider can be controlled, it would seem that economic entomologists might well afford to give the matter of its further development serious consideration. The method offers a new approach in pest control, particularly with plants which are grown for ornamental purposes. —1-6-40.

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Particle Size of Paris Green as Related to Toxicity and Repellency to the Mexican Bean Beetle

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The particle size of a powdered stomach insecticide has been considered one of its important characteristics. It has frequently been stated that the smaller the particles the better the coverage that could be obtained with a given weight of material. It has also been pointed out that although extremely fine particles can be used in spray suspensions, in dusts these have certain disadvantages. While these general principles are recognized, comparatively few papers have been published in which the relationship between definite particle sizes of materials and reactions of insects to them has been studied. Shipitzina (1935) found that first-instar mosquito larvae (*Anapheles maculipennis messeae*) ingested quartz particles with maximum diameters ranging from 22.8 to 34.2 microns and that fourth-instar larvae ingested particles 68 to 165.3 microns in size.

In a study of the toxicity of a number of samples of calcium arsenate to fifth-instar cotton leaf worms (*Alabama argillacea* Hbn.). Gaines (1938) found that one of the coarsest samples was six times and one of the medium samples was four times as toxic as one of the finest ones. Nelson and Cassil (1937) showed that there was considerably more water-soluble arsenic by the New York method in the coarse and medium calcium arsenates than in the fine, which may have influenced the toxicity of these three samples. Goodhue (1937), in describing the particle size of the same samples, states that 26 per cent of the coarse, 50 per cent of the medium, and 87 per cent of the fine sample was below 6 microns in diameter. These figures indicate that there was considerable material below 6 microns in diameter in all three calcium arsenates used by Gaines. Smith *et al.* (1938) found a highly significant negative correlation between the net mortality of the boll weevil (*Anthonomus grandis* Boh.) and particle size (per cent below 10 microns diameter) of 20 calcium arsenates. They state in explanation of these results that chemical differences among the samples tend to overshadow the normal effect of particle size.

Siegler & Goodhue (1939) studied the effect of particle size on the toxicity of calcium arsenate, paris green, cryolite, phenothiazine and lead arsenate to codling moth (*Carpocapsa pomonella* (L.)) larvae. They found no great differences in fractions with "mid-sizes"* between 2 and 28 microns; however, those with mid-sizes between 4.5 and 18 microns were

* The mid-size is that size which divides each fraction into two equal parts by weight.

generally slightly superior to fractions with mid-sizes 28 to 29 microns or 2 to 4 microns in diameter. A fraction of phenothiazine with a mid-size of 45 microns caused less than one-half the mortality caused by fractions with mid-sizes 15 and 4 microns in diameter. With the possible exception of phenothiazine, all the fractions (mid-sizes 4.5 to 18 microns) that gave slightly higher mortalities contained from 11 to 57 per cent of particles below 6 microns.

These papers show that the insecticide fractions used, besides varying in chemical composition in some instances, have not been of well-defined particle size, that is, with practically no overlapping from one fraction to another. Probably as a result of this there has not been found a logical correlation between toxicity and particle size of insecticides. A possible explanation for such findings is that the fine particles have been present in sufficient quantities in the coarser material to lessen any toxicity differences that might exist. With these points in mind, three well-defined fractions of paris green (Fig. 1) were prepared and tested as stomach insecticides.

Several methods of segregating the desired particle sizes were tried, but no single one could be used in obtaining all three of the desired fractions. The method used for each fraction is briefly described below.

Fraction Size 22 Microns.—The original sample of a commercial paris green was fractionated mechanically by shaking in a nest of sieves. The particles passing the 200-mesh and retained by the 325-mesh sieve were kept. Even after this treatment fine particles adhered to the large ones, thus making it necessary to treat the sample further by repeated controlled sedimentation and decantation with 95 per cent ethyl alcohol.

Fraction Size 12 Microns.—That part of the paris green which had passed the 325-mesh sieve was subjected to a controlled sedimentation and decantation with alcohol, so adjusted as to select particles with falling velocities between 1.7 and 3.0 centimeters per minute. Particles of this size offered no difficulty in sticking together when the alcohol was volatilized.

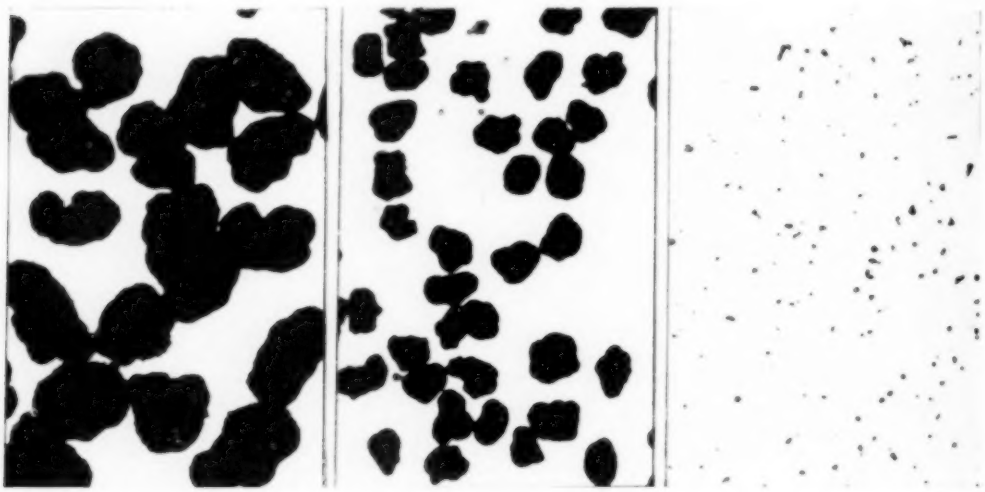

FIG. 1.—Photomicrograph of distribution of particles in paris green fractions. Left to right, 22, 12, and 1.1 microns (×200).

Fraction Size 1.1 Microns.—This fraction could not be obtained by sedimentation because the particles became cemented together again upon evaporation of the alcohol. Consequently a Federal Air Classifier was employed for this separation.

The sharp degree of separation attained in these fractions is illustrated in figure 1. Each group of particles has been magnified 200 times, showing the relative homogeneity of the particles in each fraction.

The chemical and physical data are presented in table 1. All chemical analyses

in this table were made according to the methods of the Association of Official Agricultural Chemists. It may be noted that the average particle diameter quoted does not fall within the particle-size range given. There are two possible reasons for this apparent discrepancy. First, the average particle sizes as estimated by microscopic examination have a tendency to be higher than the true value in the case of these nonuniform particles, since in general only the two largest dimensions are visible. Second, the values obtained by the air-permeability method by Gooden and Smith (1940) are likely to be slightly low, because of the porosity or imperfect solidity of the individual particles.

The sample of commercial talc used as an inert control in the dusting experiments had an average "surface weighted diameter" of 4 microns and a range of 1 to 50 microns as measured microscopically.

Table 1.—Chemical and physical data on three fractions of paris green used for toxicity tests.

Physical Data			Chemical Data		
Average Particle Diameter, Microns*	Particle Size Range, Microns†	Surface Area Per Gram Square Centimeters	Cupric Oxide, Per Cent	Arsenious Oxide, Per Cent	Water-Soluble Arsenic Trioxide, Per Cent
22	25–60	850	29.50	56.60	1.60
12	12–25	1,550	29.17	56.23	1.77
1.1	<4	17,000	30.60	53.01	4.68

* Surface weighted diameters obtained from apparatus designed by Gooden and Smith (1940).
† Values estimated by microscopic examination.

Biological Tests.—Second-brood and third-brood Mexican bean beetle (*Epilachna varivestis* Muls.) adults and third-brood larvae collected from bean fields near Beltsville, Maryland, were used as test insects. When tested the second-brood beetles were old but many of the third-brood beetles were comparatively young. The beetles were starved for 24 hours before being placed in the test cages.

Bean leaves were kept turgid by inserting their petioles into vials of water through stoppers so fitted that air could enter the vial as the leaf transpired but water could not run out. White flannel was pressed against the lower surface of the leaves and around the petioles to keep the beetles from feeding on the untreated surfaces. The pubescence of the bean leaves and the nap of the cloth made the leaves and cloth cohere tightly. The edges of the leaves were trimmed so that the leaf and the vial of water would lie in the bottom of a 15-centimeter petri dish. After the leaves were infested a 16-mesh screen was placed over the dish.

Leaves were sprayed with the aqueous suspensions by passing them through the spray on a conveyor belt. The leaves were sprayed once and then returned through the sprayer in reverse position to increase the uniformity of deposit. The sprayer was adjusted so that two spray applications gave a deposit that did not run when the leaf surface was held in a vertical position. This type of coverage prevented the formation of large drops and subsequent heavy deposits on some areas of the leaf.

Preliminary spray tests gave deposits of 75, 27, and 16 micrograms of paris green per square centimeter when equal suspension concentrations were used for the 22-, 12-, and 1.1-micron fractions, respectively. Consequently, the aqueous concentrations were adjusted to give approximately equal deposits (Table 2).

Injury to the sprayed foliage was practically eliminated by treating only the upper surfaces of the leaves and then placing them in a gentle breeze from an electric fan which evaporated the water within 5 minutes.

Deposits for analysis were obtained by placing an 8 by 10 centimeter glass slide on the conveyor with each leaf being sprayed. The slide was then washed with 10 per cent hydrochloric acid, and the amount of arsenic present determined by the method of Cassil and Wichmann (1939).

Dusts were applied in a cylindrical dust settling chamber about 41 centimeters in diameter and 51 centimeters in height. From two to four blasts of air under 25 pounds pressure dispersed the dust from a cup 3 centimeters in diameter mounted in the chamber. The leaves to be dusted were placed on a circular revolving platform of the same diameter as the dust chamber and about 15 centimeters below it. Preliminary tests had shown that if the platform made 30 to 40 revolutions per minute the variation in deposit was materially reduced as compared with deposits on a stationary platform, but a heavier deposit was obtained near the

center of the revolving platform than near the periphery. To balance this effect as far as was practical, the treated surface of each leaf was dusted twice, with its position in relation to the center of the revolving platform reversed the second time. A 100 square centimeter aluminum plate was placed on the revolving platform in a position comparable with that of each group of leaves dusted and the deposit of dust on the plate weighed.

Treated leaves and untreated leaves for controls were infested and placed in cal methods could be applied to the results. Each particle size of paris green and the check was tested three times with about 20 beetles each on 4 separate days, thus giving a total of 48 mortality counts for the spraying and 48 for the dusting procedure. In connection with the dusting experiments, two tests of talc were carried out on 2 separate days, to evaluate the effect of inert particles. The beetles were weighed in groups of about 20 each.

RESULTS.—The data in table 2 and figure 2 show that the toxicity and the

Table 2.—The effect of particle size of paris green on the feeding and mortality of Mexican bean beetle adults.

SERIES	INSECTICIDE USED	PARTICLE DIAMETER, MICRONS	AVERAGE DEPOSIT, MICROGRAMS PER SQUARE CENTIMETER	AMOUNT INGESTED PER GRAM OF INSECT			MORTALITY IN 48 HOURS PER CENT
				Leaf Area, Square Centimeters	Insecticide, Micrograms	Surface Area of Insecticide, Square Centimeters	
			Spray				
1	Paris green	22	32	6.5	208	0.18	29
2	Paris green	12	31	3.9	121	0.19	40
3	Paris green	1.1	32	1.1	35	0.59	53
4	None		0	34.6	0	0	13
Difference in mortality required for significance at odds of 99 to 1, *10.3*							
			Dusts				
5	Paris green	22	110	4.5	449	0.42	43
6	Paris green	12	105	2.3	238	0.37	61
7	Paris green	1.1	105	0.3	34	0.52	88
8*	Talc	4	108	44.8	4,841	26.14	19
9	None		0	82.4	0	0	15
Difference in mortality required for significance at odds of 99 to 1, *14.0*							

* Each series consisted of 12 tests of 20 beetles each, except 8 which consisted of 4 tests.

a cabinet at about 24 degrees C. and 60 to 80 per cent relative humidity. Glass plates were laid on the screen tops of the petri dish cages to retard transpiration.

The total area of the leaves and the amount eaten were recorded as contact photographic prints and were measured with a planimeter or by means of paper ruled in square millimeters.

An effort was made to maintain a constant area of leaf surface in comparative tests. The sprayed leaves averaged 58 square centimeters for paris green suspensions and 68 square centimeters for water. Dusted leaves averaged 74 and 55 square centimeters for paris green and talc, respectively. The untreated leaves averaged 80 square centimeters.

The tests were so designed that statistiamount of feeding are related to the particle size of paris green. The fraction with an average diameter of 1.1 microns caused the greatest mortality both as a spray and as a dust, and foliage sprayed (Fig. 2) or dusted with it was eaten the least. The 12-micron fraction occupied an intermediate position both in mortality and amount of feeding, and the 22-micron paris green caused the lowest mortality and was eaten in the largest amounts both as a spray and as a dust. The leaves that were dusted with talc did not cause a significantly higher mortality than the untreated control leaves and were eaten in far larger amounts than any of the paris green treated foliage.

Upon subjecting the data in table 2 to the analysis of covariance a correlation of

−0.9996 was found with a significant level of 49 to 1. This proves from a statistical point of view that the apparent, and altogether logical, increase of toxicity with decreasing particle size is real. This correlation existed in spite of the much larger quantities of the 22- and 12-micron fractions apparently ingested by the insects.

With the 1.1-micron fraction the feeding on sprayed foliage was confined to several small areas as contrasted with a few larger areas on dusted foliage.

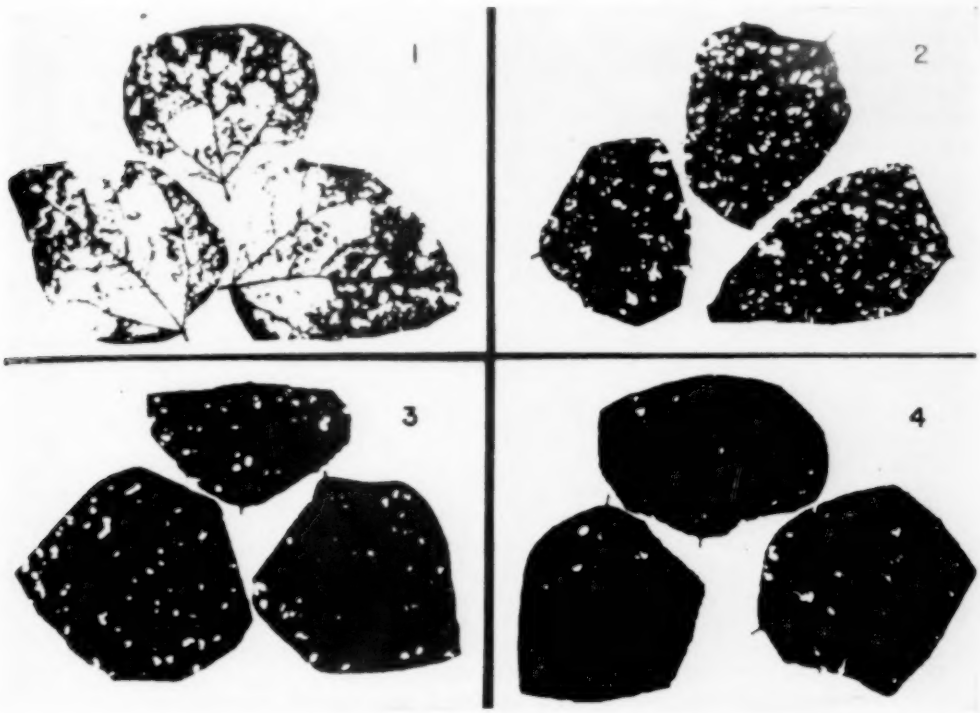

Fig. 2.—Representative sprayed bean leaves showing the feeding by the Mexican bean beetle adult. Aqueous sprays contained (1) no insecticide, (2) 22-micron, (3) 12-micron, and (4), 1.1-micron fraction of paris green. (One-half natural size.)

It was observed that the appendages and ventral surfaces of the beetles that had been on foliage dusted with the 1.1-micron paris green were sufficiently coated with the insecticide to have a distinct green color. Beetles feeding on foliage dusted with the 22- or 12-micron paris greens and beetles on foliage sprayed with all three fractions did not display this coloration.

The 1.1-micron fraction shows the largest surface area of insecticide ingested, in spite of the fact that the smallest leaf area and weight of insecticide were ingested. The difference between the 22-micron fraction and the 12-micron fraction was not large.

The weighing of 1,243 beetles in groups of about 20 each gave an average of 27.2 beetles per gram of body weight, a maximum day-to-day variation of 16.5 per cent, and a maximum between-series deviation of 2.1 per cent in total body weight. The field-collected beetles had a sex ratio of 50:50, whereas 55 and 60 per cent of the insects killed by the spray and dust treatments, respectively, were females.

In four preliminary series of spray tests with second-instar Mexican bean beetle larvae, using about 20 insects in each of three tests per series, deposits of 16, 14, 15, and 0 micrograms per square centimeter of the 22-, 12-, and 1.1-micron paris greens and water alone caused 35, 46, 85, and 14 per cent mortality, respectively.

Discussion.—The ingestion of the insecticide by the insect is of primary im-

portance in stomach insecticides. Any reduction in feeding caused by the insecticide will influence the results obtained and may be the controlling factor. It can be shown by calculation from the amount of untreated leaf area eaten, that, if the three fractions of paris green used in these experiments had not influenced the feeding of the beetles during the 48 hours of the test, each gram of insects would have ingested from 34.6 to 82.4 square centimeters of bean leaf, or from 1,090 to 8,800 micrograms of paris green. This would undoubtedly have been a lethal dose in most instances, since these amounts are from 5 to over 200 times as much as was actually eaten, depending on the particle fraction, method of application, and vitality of the beetles.

The data in table 2 and illustration in figure 2 show clearly that each fraction of paris green influenced the feeding to a different degree. If it is postulated that paris green, regardless of its particle size, has no contact action on the Mexican bean beetle and that all the beetles fed equally, then it is evident from table 2 that the finest material not only caused the highest mortality but permitted the least amount of feeding. These data indicate that one of the most important characteristics of a stomach insecticide for non-boring insects is its effect on the feeding of the pest.

It is of especial interest to consider the possible reasons for the different amounts of foliage ingested in relation to the particle size, since the average deposits of the three fractions were practically the same. It appears that the coarser the paris green the more of it was eaten, which indicates that some factor or factors other than the amount of the insecticide ingested must control the amount of feeding on the treated foliage.

The surface area of the insecticide ingested per gram of insect indicates the probability that the larger surface area of the 1.1-micron fraction and the greater amount of water-soluble arsenic in it allowed rapid absorption of the insecticide and caused the insects to become ill and stop feeding in a short time. In comparison with this the 22- and 12-micron fractions, which had relatively small surface areas and less water-soluble arsenic, did not affect the insects so rapidly and larger amounts were ingested before the insects stopped feeding.

As previously stated in the results, visible quantities of the paris green adhered to the beetles fed on foliage dusted with the 1.1-micron material. Part of this material may have entered the insects, causing a toxic action. Since there was no visible evidence of adherence of the 22- and 12-micron fractions, their contact toxic action was probably much less. It was also possible that the mortality was affected by the greater quantity of water-soluble arsenic in the 1.1-micron fraction. Any contact effect probably was combined with that of the insecticide ingested by the feeding of the insects on the treated leaves.

The effectiveness of spray and dust treatments cannot be compared from the data in table 2 because of the variation in the beetles. In the spray tests old second-brood beetles were used whereas those used in the dust tests were young third-brood beetles. Some idea of the relative vitality of the two groups of insects can be obtained by comparing the unpoisoned leaf areas ingested per gram of insects feeding on the foliage.

Under field conditions paris green is very toxic to bean foliage, but under the indoor and quick-drying conditions of these tests, where only the upper surfaces of the leaves were sprayed, practically all the toxic effect was eliminated.

The tests with the second-instar larvae, while not conclusive in themselves, indicate the same trend of toxicity as the more extensive tests with the adult beetles.

SUMMARY.—Experiments have shown that paris green particles with an average diameter of 1.1 microns caused higher mortalities of the Mexican bean beetle (*Epilachna varivestis* Muls.) and permitted less feeding when applied, either as a spray or as a dust, to bean foliage, than did particles of 12 microns, which were intermediate, and 22 microns, which caused the lowest mortality and permitted the greatest amount of feeding.—2-12-40.

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Methyl Bromide in Aqueous Solution to Control *Pantomorus leucoloma* and *P. peregrinus*

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How to destroy infestations of the larva of the white-fringed beetle (*Pantomorus leucoloma* (Boh.)) and the closely related species *P. peregrinus* Buch. in the soil of balled-in-burlap nursery stock is a problem that came into existence with the promulgation, in January 1939, of the Federal quarantine against these insects. Preliminary experiments with methyl bromide applied in various ways to balled-in-burlap material showed that when this chemical was dissolved in denatured ethyl alcohol and the solution in turn dissolved in water, a potent insecticide resulted. When this aqueous solution of methyl bromide and ethyl alcohol was sprinkled on boxes filled with sand in which were plunged burlapped soil balls infested with *Pantomorus* larvae, mortality of the insects resulted, the degree of mortality being affected by such factors as the percentage of methyl bromide contained in the solution, the rate at which it was applied, the length of time the balls were allowed to remain in the sand box, the temperature, and other factors of lesser importance. The purpose of this paper is to present detailed data on the effect on infestations of *Pantomorus*, in burlapped balls of earth, produced by treatment with an aqueous solution of methyl bromide.

METHOD OF PROCEDURE.—In the experiments reported in this paper the larval stages of *Pantomorus leucoloma* and *P. peregrinus* were used. Infested burlapped balls of earth were plunged in water-tight sand boxes 1 foot deep, with at least a 2-inch interspace between the balls and between the top of the balls and the surface of the sand and the bottom of the balls and the bottom of the box. Clean, white river sand free of organic matter was used as a plunging medium in the sand boxes. The aqueous insecticidal solution contained 0.3 per cent of methyl bromide and 0.6 per cent of denatured ethyl alcohol and was applied from a gardener's sprinkling can to the sand box at the rate of 40 gallons per 100 square feet of surface area. The balls of earth were allowed to remain in the sand box for various periods of time. The temperature of the sand during this period was determined by a maximum-minimum thermometer or a distance thermograph, the temperature being taken at the center of the sand in the box. The temperatures at which the experiments were carried out usually averaged between 70 and 80 degrees F. At the expiration of the period of treatment the burlapped balls were removed from the sand boxes and set aside for 24 hours, and at the end of this additional period the insect material was removed and kept for observations on mortality. In this work the infested burlapped balls of soil were grouped according to their minimum diameters and the data are grouped accordingly in the tables. The maximum diameter, as given in the tables, for a particular group of burlapped balls usually ranged from slightly above the minimum diameter to

[1] The work reported in this paper was done under the direction of Dr. Lon A. Hawkins, Division of Control Investigations.

the tabular values given for the group. In each group the balls were fairly uniform in size and shape.

RESULTS OF EXPERIMENTS.—Table 1 shows the mortality of larvae of *Pantomorus leucoloma* in 4- to 7-inch burlapped balls of alluvial sandy clay at New Orleans. Treatments of 8, 12, 18, and 24 hours' duration were used. The 8-hour exposure failed to give complete mortality in balls 5 and 7 inches in diameter. The 12-hour exposure gave complete mortality in balls having a diameter of 5 inches but not in those 6 and 7 inches in diameter. The 18- and 24-hour exposures gave complete mortality in balls 4, 5, and 6 inches in diameter but not in those 7 inches in diameter. Temperatures in these experiments ranged from 68 to 82 degrees F., the range and average being given in the table for each series of tests. The averages among the series of experiments ranged from 72.3 to 78.5 degrees F.

Table 2 shows the percentages of mortality of larvae of *Pantomorus peregrinus* obtained in 3- to 7-inch burlapped balls of sandy loam in Gulfport. Exposures of 2, 4, and 6 hours were used. A 2-hour exposure was not sufficient to produce complete mortality of the larvae in balls having a minimum diameter of 4 inches, but was sufficient for balls 5 inches in diameter. This apparent discrepancy is perhaps due to the small number of larvae used in the tests with the 5-inch balls. The 4- and 6-hour exposures gave complete kills of test larvae in balls ranging in diameter from 3 to 7 inches, inclusive. The temperature in the experiments included in table 2 ranged from 73 to 86 degrees F. The averages among the series of experiments ranged from 76.3 to 80.8 degrees F.

Table 1.—Results of experiments with methyl bromide (0.3 per cent) in aqueous solution sprinkled on sand boxes containing plunged burlapped balls infested with larvae of *Pantomorus leucoloma* at the rate of 40 gallons per 100 square feet of surface area. New Orleans, La.

Series No.	Temperature in Degrees F.		Number of Soil Balls	Diameter of Soil Balls in Inches		Larvae		
	Range	Average		Minimum	Maximum	Total Used	Number Killed	Per Cent Killed
8-Hour Treatment in Plunging Box								
1	75–80	78.5	1	5	11	9	5	55.6
2	75–80	78.5	4	7	13	56	55	98.2
12-Hour Treatment in Plunging Box								
3	74–78	76.0	2	5	7	18	18	100.0
4	74–78	76.0	1	6	7	8	5	62.5
5	74–78	76.0	3	7	12	47	41	87.2
18-Hour Treatment in Plunging Box								
6	75–82	78.5	1	4	8	5	5	100.0
7	68–82	74.0	15	5	10	117	117	100.0
8	68–82	72.8	7	6	10	22	22	100.0
9	68–82	72.8	9	7	15	114	112	98.3
24-Hour Treatment in Plunging Box								
10	68–78	72.3	2	4	8	30	30	100.0
11	68–79	74.5	8	5	10	85	85	100.0
12	68–80	75.2	11	6	14	117	117	100.0
13	71–80	74.0	6	7	17	96	92	95.8
Check (Untreated): 24-Hours in Plunging Box								
14	74–78	76.0	2	4	8	20	3	15.0
15	74–78	76.0	1	5	8	13	0	0.0
16	74–78	76.0	1	6	9	13	1	7.7
17	74–78	76.0	2	7	15	26	7	26.9

EFFECT ON PLANTS.—Preliminary results of experiments to determine the effect of the insecticide on plants have been encouraging. It appears that such ornamental plants as *Gardenia*, *Nandina*, *Podocarpus*, *Pyracantha*, some varieties of arborvitae, sweet olive, and certain others suffered little or no retardation in growth following treatment.

DISCUSSION OF RESULTS.—Of interest was the finding that considerably shorter exposures gave complete mortalities of the larvae of *Pantomorus peregrinus* than

were required for *P. leucoloma*. A 4-hour exposure produced a complete kill of larvae of *P. peregrinus* in balls 7 inches and smaller in diameter, whereas an 18-hour exposure was required to give the same result with larvae of *P. leucoloma* in balls 6 inches and smaller in diameter. Unpublished evidence at hand indicates that this seeming difference in resistance larval infestations of *Pantomorus leucoloma* and *P. peregrinus* in burlapped balls of earth such as would be encountered on the roots of nursery stock. Results of a limited number of experiments showed that when infested balls were plunged in sand boxes that were 1 foot deep, with a 2-inch sand space on all sides of the balls, and the insecticide applied at the rate of

Table 2.—Results of experiments with methyl bromide (0.3 per cent) in aqueous solution sprinkled on sand boxes containing plunged burlapped balls infested with larvae of *Pantomorus peregrinus* at the rate of 40 gallons per 100 square feet of surface area. Gulfport, Miss.

Series No.	Temperature in Degrees F.		Number of Soil Balls	Diameter of Soil Balls in Inches		Larvae		
	Range	Average		Minimum	Maximum	Total Used	Number Killed	Per Cent Killed
			2-Hour Treatment in Plunging Box					
1	74–78	76.3	7	4	7	41	39	95.1
2	76–78	77.0	2	5	7	13	13	100.00
			4-Hour Treatment in Plunging Box					
3	73–86	78.9	7	3	5	18	18	100.0
4	73–82	78.0	17	4	7	59	59	100.0
5	73–86	78.3	27	5	10	113	113	100.0
6	75–86	79.1	24	6	9	71	71	100.0
7	73–86	78.9	15	7	11	140	140	100.0
			6-Hour Treatment in Plunging Box					
8	73–86	79.0	3	3	5	14	14	100.0
9	73–79	76.4	7	4	7	31	31	100.0
10	73–86	78.1	10	5	7	63	63	100.0
11	76–86	80.8	2	6	9	7	7	100.0
12	73–86	78.7	5	7	11	55	55	100.0

to the insecticide is due mainly to the character of the soil of which the burlapped balls were composed. In New Orleans and vicinity where the experiments with *P. leucoloma* were carried out the soil is a dense, compact sandy clay of alluvial origin. In Gulfport and vicinity where *P. peregrinus* is found the soil is a loose and porous sandy loam.

SUMMARY.—An aqueous solution containing 0.3 per cent of methyl bromide and 0.6 per cent of denatured ethyl alcohol was found to be of value in destroying 40 gallons per 100 square feet of surface area, complete mortality of larvae of *P. leucoloma* was obtained in balls 6 inches and smaller in diameter with an 18-hour exposure, and complete mortality of larvae of *P. peregrinus* was obtained with a 4-hour exposure. This apparent difference in the susceptibility of the larvae of these two species of *Pantomorus* is due to the different types of soil found in the two localities where the experimental work with the fumigant was carried on.—1-6-40.

AS A PROTECTION for the long established coffee industry of Puerto Rico against the destructive coffee rust, the coffee berry borer and other pests, Federal Plant Quarantine No. 73 had been established, effective April 1, 1940, which prohibits entry into that island from foreign countries of coffee plants, plant parts, berries, and unroasted coffee beans, with provision, however, for entry under regulation of small samples of coffee beans and for shipments entering at San Juan in transit to the mainland or foreign countries. This quarantine does not affect the importation of foreign coffee into the United States mainland.

THE California quarantine relating to the peach mosaic disease was revised effective November 18, 1939, adding to the infected area all of Orange County and part of Imperial County, and releasing from the quarantine restrictions portions of the counties of Los Angeles, San Bernardino, and Riverside, now declared to be free from the mosaic disease. Changes were also made in the quarantine provisions.

Winter Mortality of the Black Scale (*Saissetia oleae* Bern.) on Oranges in California

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Praise or blame for a black scale condition that may develop after an orange grove has been sprayed or fumigated does not necessarily rest solely upon the efficacy of the material applied, the dosage, the thoroughness of the application, the time of application, the work of parasites, the number of insects present when the treatment is made or the number that survive the treatment. Winter mortality is an important factor that has apparently been overlooked in considerations on the control of this pest. The studies herein reported indicate that where the infestation is heavy at the time of treating, winter mortality is probably the determining factor in any decrease or increase in infestation as compared with the preceding year. That is to say, the success or failure of a treatment, as ordinarily judged by the degree of infestation in spring and early summer of the following year, depends to a large extent upon the number of insects that die of natural causes subsequent to the treatment.

SEASONAL HISTORY AND CONTROL OF BLACK SCALE.—A brief statement of the seasonal history and control of the black scale is made for the information of readers who may not be familiar with this major pest of oranges in California. The female scale attains full size about the first of June. During the months of June and July she lays 1500 or 2000 eggs. Hatching is usually complete by the tenth of August. Spraying and fumigating are done during the following two or three months when the insects are sufficiently small to be vulnerable to the treatments. The newly hatched insects settle upon the leaves and remain there for 6 or 8 months. In late winter they migrate from the leaves to the twigs and terminal branches. As is shown by the present studies, a high percentage perishes during this migration period. During April and May the insects rapidly grow to full size and excrete copious amounts of honeydew which falls onto the leaves and oranges. A sooty mold fungus grows on the honeydew and the trees take on an unsightly, dirty, black appearance. If the trees are less dirty and have fewer scales than at the same time the preceding year, the spray or fumigation treatment, made the preceding August, September or October, is considered to have been satisfactory. If the trees are more dirty, the treatment is blamed.

MORTALITY STUDIES IN TWO TEN-ACRE ORANGE GROVES.—The first statistical data on winter mortality were secured in connection with spraying experiments made in two ten-acre orange groves. The study in grove A covered the black scale season (August to June) of 1931–32, and the study in grove B covered the season of 1932–33. A month after spraying, an examination was made of 20 leaves selected at random from each tree in the groves, and the number of live insects was recorded. The following June an examination was made of 20 "units" selected at random from each tree and the number of full-grown insects was recorded. The "unit" was a terminal portion of a branch, 12 inches in length. There was an average of 24 leaves to the unit in grove A and 20 leaves to the unit in grove B. In the summary of data given in table 1, the leaf count is shown as the average number of

Table 1.—Mortality data based on scale counts on every tree in two 10-acre groves.

	Live Insects to 24 Leaves After Spraying in September, 1931	Live Insects to 24 Leaves (1 "Unit") in June 1932	Per Cent of Insects Dying During the Winter
	GROVE A		
Sprayed trees	1.5240	.6617	56.58
Unsprayed trees	63.3216	19.4961	69.21
	Live Insects to 20 Leaves After Spraying in September, 1932	Live Insects to 20 Leaves (1 "Unit") in June, 1933	Per Cent of Insects Dying During the Winter
	GROVE B		
Sprayed trees	3.536	.3851	89.11
Unsprayed trees	42.642	6.7750	84.11

insects to 24 leaves in grove A and 20 leaves in grove B, in order to afford a direct comparison with the average number of insects to the "unit" in the respective groves.

As shown in table 1, 56.58 per cent of the insects on the sprayed trees in grove A, and 69.21 per cent of those on the unsprayed trees, died from natural causes

Table 2.—Showing the number of live black scale per "unit" at intervals from the time of spraying, August 27, 1935, to June 10, 1936.

Sex	August 27	October 23	January 8	March 16	June 10
Males and females	1677.76	24.6			
Females		20.95	17.5	4.2	1.40

during fall, winter and spring. The higher mortality on the untreated trees may have been the result of the very dense insect population. Some twigs were so densely covered as to indicate that many insects had probably not found room enough to settle and develop. In grove B, the following year, 89.11 per cent of the insects on the sprayed trees, and 84.11 per cent on the unsprayed trees, died from natural causes during fall, winter, and spring. The percentage that died from natural causes in grove B was nearly as large as the percentage killed by the spray in certain tests. The data given in table 1 show that in September grove B had over twice as many insects as grove A. The following June, however, grove B had only about one-half as many insects as grove A.

MORTALITY STUDIES OF BLACK SCALE ON TWO TREES.—To obtain further data on winter mortality, a study limited to two orange trees was made during the black scale season of 1935–36. The results of this study are indicated in table 2. There was an average of 14.7 leaves to the "unit." At the time the trees were sprayed August 27, 1935, the counts showed an average of 1677.76 live insects (female and male) to 14.7 leaves. This represented a heavy infestation. Counts made October 23 gave an average of 24.6 insects to 14.7 leaves. It may be assumed that the spraying was responsible for reducing the population per "unit" from 1677.76 to 24.6. This represents a kill of 98.53 per cent. There were 20.95 female insects to the "unit" on October 23. Since the males emerge as winged forms during the winter, they were not recorded in the counts made subsequent to October 23. Counts made on January 8, 1936, gave 17.5 female insects per "unit." The examination of numerous twigs failed to reveal insects on the bark and it was supposed that the migration from the leaves to the bark had not yet started. However, some migration may have taken place, and such migration, together with a limited amount of natural mortality, would account for the fact that the female insect population during the period from October 23 to January 8 had decreased from 20.95 to 17.5 insects per "unit."

On March 16, 1936, when the fourth count was made, a large percentage of the insects had migrated from the leaves to the twigs. The counts showed an average of 4.28 female insects to the "unit." It would appear, therefore, that owing to natural mortality incident to migration, the insect population decreased 75.5 per cent between January 8 and March 16. The last count was made on June 10. At that time the insects were full-grown and all were established on the twigs and terminal branches. The counts showed an average of 1.4 female insects to the "unit." This represents a natural mortality of 93.32 per cent for the period October 23, 1935 to June 10, 1936.

If this natural mortality had not occurred, the grove would have shown an exceedingly heavy infestation, with 20.95 insects per "unit," and the treatment would have been adjudged a miserable failure. As it turned out, the grove showed a lighter infestation than existed the preceding year and the grower was well satisfied with the results of the spray treatment. If the natural mortality had been 89.11 per cent as was the case in grove B in 1932–33, there would have been 2.28 insects per "unit" or nearly twice as many as actually occurred on June 10, 1936. In that event, the grower would have much dissatisfied with the results of the treatment. If the natural mortality had been 56.58 per cent, as it had been in grove A in 1931–32, there would have been 9.09 insects per "unit" which would represent an extremely heavy infestation.—1-6-40.

Fumigation of Sacked Grain with Chloropicrin

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There has long been a need for an efficient method of treating sacked grain infested with insect pests. This problem has been of especial importance to commercial seedsmen. Insect damage need not be very extensive to cause losses in sales and trade prestige; in fact, the mere presence of insects will hurt the seedsman's trade. The work of this paper is concerned wholly with control of insects in sacked grain by fumigation with chloropicrin.

EXPERIMENTAL METHODS.—The work was done in a fumigation vault having a volume of 1,000 cubic feet. Vault temperatures throughout the fumigations averaged approximately 75 degrees F. ranging from 68 to 84 degrees. An average relative humidity of 45 per cent was maintained. Approximately 700 pounds of grain were in the vault during each fumigation.

In general, the bags† used in this experiment were of the following main types as to gas-holding properties: (1) extremely porous cloth bags, such as the *Osnaburg* and *Drill;* (2) burlap bags lined with either a single or a double layer of glued or asphalted *Kraft* paper; and (3) cloth and burlap bags lined with a glassine-like plastic, commercially known as *Pliofilm*.

Wheat was used as the experimental grain. Quantities of insect-infested wheat varying from 40 to 60 pounds were used, depending upon the capacity of the sack.

Mixed cultures of coleopterous stored grain insects were used, including the following species: the red flour beetle, *Tribolium castaneum* (Hbst.); the lesser grain borer, *Rhizopertha dominica* F.; the rice weevil, *Sitophilus oryzae* (L.); the granary weevil, *Sitophilus granarius* (L.); and the flat grain beetle, *Laemophloeus minutus* Oliv. However, due to the fluctuation in numbers of the various species in culture, data for some of them are not consistently present throughout.

Results were checked by placing infested wheat samples in various situations in the filled bags. Two types of samples were used. One type consisted of 115 grams of infested wheat enclosed in a thin cloth bag. These sack samples, while giving only an approximate idea of the mortality, were particularly valuable since they included undisturbed immature stages and could be held over to determine the degree of survival of these stages. The other type consisted of known numbers of living adults in small wheat-filled boxes which had the tops and bottoms replaced by stiff gauze. From these box samples the percentage mortality of the adults could be obtained.

The mortality data were obtained by sifting the insects from each sample and then leaving the sample under a 200 watt lamp for a few moments. This last measure drove out all adult insects which had resisted the sifting by being concealed inside of hollow kernels. After all living and dead adults were sifted from each sack sample, the remaining grain was placed in a two-quart jar, sealed, and incubated for a period of six weeks. The appearance of living adults at any time in this period was taken to indicate survival of immature stages. Cotton *et al*[1] used this method in checking the results of fumigation upon the immature stages of *Sitophilus*.

It was quickly apparent that the type of sack used directly influenced the dosage of the fumigant needed for complete control, and also directly determined the method of fumigation necessary. Two means of fumigation were tested: the injection method and the vault method. The latter is the one in common usage. Injection fumigation has been tried in dried fruit fumigation but there are no published records of tests of that method in the fumigation of sacked seeds.

Chloropicrin was injected into the sack in quantities proportional to the volume of the filled sack which was calculated from the weight of the grain in the sack. Dosage relations of pounds of chloropicrin per 1,000 cubic feet were then converted into cubic centimeters, and the number of

* The investigations reported here were made under a Research Fellowship supported by Innis, Speiden and Co. of New York City. The work was done under the direction of W. P. Flint, Chief Entomologist of the Illinois Natural History Survey Division and the Illinois Agricultural Experiment Station. Dr. M. D. Farrer, Research Entomologist of the Illinois Natural History Survey Division, gave much helpful technical advice. This report was submitted in partial fulfillment of the requirements for the degree of master of science in entomology in the Graduate School of the University of Illinois, 1939.

† Many of the bags used in this work were furnished by the Bemis Bag Co. and the Fulton Bag Co., both of St. Louis, Missouri.

[1] Cotton, R. T., G. E. Wagner, and H. D. Young, 1937. Heavier than air fumigants and their relations to methods of fumigation for insect control. Nat. Grain J. 21(11):10–12.

cubic centimeters needed for the volume of the sack of grain was determined.

In the injection fumigation the filled sacks were laid on the floor of the chamber. A slender glass pipette was inserted through the center of the upper sack surface and the required dose of chloropicrin was injected into the pipette from a 10 cc. hypodermic syringe. Because the experimental doses were very small (five pounds of chloropicrin per 1,000 cubic feet is equal to 1.7 cubic centimeters per bushel of sacked wheat), a rubber bulb and tube were connected to the pipette after the injection and air was forced through to drive out any drops of liquid that might be clinging to the glass. The perforation in the sack was covered by a small piece of gummed tape. Later, in the practical application of this method, a long stout needle was used directly from a one-pound container, and so adjusted as to inject a known amount at each stroke of a plunger. Grain containing quantities of dust is difficult to fumigate by this method since the dust soon clogs the aperture in the needle. This experimental injection fumigation was successfully done without the protection of a gas-mask, but it is doubtful if this would be possible in large-scale operations.

In checking the results of injection fumigations, the sacks were first sampled at the end of a four-day period. At the end of a seven-day period, the sacks were removed from the chamber and the final samples were taken.

Throughout the period of fumigation, the chamber exhaust fan was allowed to run to prevent the building up of a lethal concentration around the sacks. Such gradual accumulation of the gas would be desirable in actual fumigation but in this experimental work it was thought wise to avoid it. Two sack samples and one box sample were always so placed in the filled bag as to indicate the results at either end of the bag.

In the vault fumigation the filled sacks were placed in the vault, which was then sealed, and the appropriate dose was poured in through a valve at the top. Inside the chamber the liquid ran down a long cheesecloth wick which materially increased the rate of evaporation. All the vault fumigations were for periods of 24 hours. At the end of this period, the sacks were removed to a storage room where they were sampled. They were then resealed and allowed to stand for seven days from the date of fumigation at the end of which time they were reopened and the second set of samples was removed. In this vault fumigation it was necessary to use a gas-mask equipped with a chloropicrin canister.

Table 1.—Dosage of chloropicrin required for complete kill of stored-grain insect species used in this work.

Insect	Dosage for 100 Per Cent Mortality. Pounds Per 1,000 Cubic Feet
Flat grain beetle	1
Lesser grain borer	1
Granary weevil	1½
Red flour beetle	3
Larvae—from the mixed cultures	3

An effort was made to determine the effect of chloropicrin fumigation upon the viability of seeds: corn, oats, soybeans, and wheat. Mixed samples of these were made up in cheesecloth bags which were placed in sacks that were to be fumigated. Since the moisture content of seeds plays an important part in the effect of chloropicrin on their viability, seeds with moisture content below 10 per cent were used.

RESULTS.—Results are reported here only for *Tribolium castaneum* (Hbst.). This species was consistently present in usable numbers. However, as reference to table 1 will show, it was the most difficult one to kill, and thus undoubtedly gives an adequate measure of the general results.

Table 2 shows the results obtained from the injection fumigation experiments with four main types of sacks. Each figure represents the dosage of chloropicrin which

Table 2.—Results of chloropicrin fumigation of all stages of *Tribolium castaneum* (Hbst.) in wheat, sacked in four different types of bags.

Type of Sack	Dosages for 100 Per Cent Mortality. Pounds Per 1,000 Cubic Feet: Injection Method	Vault Method
Pliofilm-lined burlap sack	1	*
Double paper-lined burlap sack	3	Above 3
Single paper-lined burlap sack	Above 8	¾
Cloth (such as the *Drill*) sack	Above 11	¾

* Even tighter than the double paper-lined burlap bag. Consequently, no tests were made with this bag.

Table 3.—Post-fumigation results obtained in the chloropicrin fumigation of *Tribolium castaneum* (Hbst.) in sacked wheat.

Type of Sack	Dosages in Pounds per 1,000 Cubic Feet	Per Cent Mortality After 4 Days	Per Cent Mortality After 7 Days
Injection Fumigation			
Single paper-lined burlap	7	24.5	100.0
Double paper-lined burlap	1½	40.4	100.0
Pliofilm-lined burlap	¾	0.0	100.0
Vault Fumigation			
Single paper-lined burlap	½	52.6	92.3
Osnaburg	¼	82.1	92.3
Double paper-lined burlap	3	90.5	100.0

gave 100 per cent mortality of all the insect species present. The *Pliofilm* lined sack gave the best results with this method, since complete control was obtained with a dosage of one pound per 1,000 cubic feet. The double paper lined burlap bag required 3 pounds of chloropicrin for complete control. Work with the single paper lined bag was given up after a dosage of 8 pounds produced a mortality of only 55.3 per cent. The results obtained from the cloth bags were very erratic and dosages as high as 14 pounds per thousand cubic feet gave incomplete control with the *Osnaburg* bag.

Table 2 similarly illustrates the results obtained from the vault fumigations. Complete control was secured with a dosage of three-fourths of a pound with the cloth bags. In the case of the single paper lined burlap bags, there seemed to be a difference in whether the paper liner was glued to the burlap or asphalted. Complete control was obtained in the glued type with a dosage of only three-fourths of a pound, while with the asphalted bag, one pound was required. With the double paper lined burlap sack, a three pound dosage gave a mortality of 90.5 per cent. In comparison to the results obtained with the porous bags, this dosage seemed rather uneconomical and so no more vault fumigations were made with the double paper lined bags.

Table 3 indicates that valuable post-fumigation results are realized by leaving the sacks undisturbed for a period of a week after fumigation.

The results from the germination experiments are as yet inconclusive (Table 4). However, from the data available, there was no significant reduction in the viability of the seeds of corn, oats, wheat and soybeans (with moisture content safe for storage) from fumigations with chloropicrin at dosages needed for complete insect mortality.

DISCUSSION.—The data presented in table 2 show that the method of fumigation must be adapted to the type of sack in which the seeds are stored. It is evident that the tight, strongly-constructed sacks may be fumigated economically only by the injection method. This may be accomplished with dosages ranging from one to three pounds per 1,000 cubic feet depending upon the tightness of the sack. A dosage of three pounds is slightly more than one cubic centimeter for each sixty-pound sack of wheat. The porous sacks are most efficiently treated by the vault method, requiring dosages of three-fourths of a pound to one pound per 1,000 cubic feet for complete control.

The work with the injection method has shown it to possess the following advantages in comparison with the vault method of fumigation: (1) The cost of equipment necessary for the fumigation is relatively low. Only a sturdy, long-needled hypodermic syringe, with a capacity of about 30 cc., and a gas-mask are needed. (2) The tight sacks necessary for use in conjunction with injection fumigation hold down or practically prevent the reinfestation of the sacked grain after it has been fumigated. (3) Small quantities of seeds may be economically fumigated. In the injection treatment only enough fumigant for the volume of the sack is used. This makes possible the economical treatment of a single sack. Injection fumigation can be of great practical value in this respect since a dealer can treat all of his shipments, no matter how small they may be. He might be hesitant, for economic

Table 4.—The effect of chloropicrin fumigation upon the germination of the seeds of oats, corn, soybeans, and wheat. Moisture content below 10 per cent.

Type of Sack	Dosage, Pounds per 1,000 Cubic Feet	Per Cent Germination			
		Corn	Oats	Wheat	Soybeans
Injection Fumigation					
Check	—	94.0	94.0	88.0	89.0
Double paper-lined burlap	2	94	87	93	93
Single paper-lined burlap	8	92	91	85	88
Check	—	98	98	98	90
Cloth (*Osnaburg*)	6	96	95	93	98
Vault Fumigation					
Check	—	96	89	83	89
Single paper-lined burlap	1	97	85	78	93
Cloth (*Osnaburg*)	1	97	91	—	89

reasons, to treat such small shipments by the vault method. The method may be applied equally well to the treatment of seeds brought into the seedhouse, in order to reduce sources of reinfestation within his storerooms.

The vault fumigation method, in contrast to the injection method, presents the following advantages: (1) It is not necessary to perforate the sack to introduce the fumigant. (2) The method is more economical, particularly when large quantities of grain are involved. The porous sacks necessary for vault fumigation are far cheaper than the gas-tight bags. The *Osnaburg* sack costs approximately eight cents whereas the double-walled bag costs approximately fourteen cents.

There is one possibility not heretofore discussed which is that even a porous bag such as the *Osnaburg* may be fumigated by the injection fumigation method provided the dosage is raised sufficiently. It would be possible to treat, successfully, small quantities of seeds sacked in porous bags, by the injection method, with a cost increase of approximately 20 per cent.

The effect of a fumigant on the viability of various kinds of seeds is of importance. Chloropicrin has been reported in the literature to have no deleterious effect upon the viability of seeds as long as their moisture content is low enough for safe storage (generally considered to be below 14 per cent). Thorough airing of the seeds before germination is also essential. The series of germination tests run on fumigated seeds in connection with this study were not extensive enough to give conclusive results but they indicate the validity of the above statement.

SUMMARY.—This investigation was concerned with the determination of the dosages of chloropicrin required for the control of insects infesting seeds stored in various types of bags. Two methods of fumigation were used: the injection of the fumigant into the sack, and the release of the fumigant into a vault holding the sacks.

The dosages found necessary for 100 per cent mortality of all stages of *Tribolium castaneum* (Hbst.) show that tight bags are best fumigated by the injection method and that porous bags are most efficiently treated by the vault method.

It was found that with either type of fumigation considerable post-fumigation mortality resulted when the grain could be left undisturbed in the sack for a period of at least seven days.

Of the five insects used in this experiment, *Tribolium castaneum* (Hbst.) in all its stages seemed the most resistant to chloropicrin fumigation.

Each of the two methods of fumigation was found to have certain advantages not possessed by the other. It is believed that supplementing one method by the other will adequately care for any situation where it may be necessary to treat for the control of insects infesting sacked grain.

There is need for more comprehensive work on the effect of chloropicrin upon the germination of seeds fumigated by the two methods described in this paper. However, the viability of the seeds of corn oats, wheat and soybeans (with moisture content low enough for safe storage) was not significantly decreased by chloropicrin fumigation with dosages necessary for complete insect control in sacked grain.—1-6-40.

The Black Hunter, *Leptothrips mali* (Fitch)

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The thrips now known as the black hunter was first described by Asa Fitch in 1855. Fitch in his original description called it the "Apple Thrips" and Watson (1918) referred to it as "The Black Garden Thrips." The latter writer (1923) renamed it the "Black Hunter" by which name it has since been known. It seems best to continue to use this latter common name for *Leptothrips mali* (Fitch) since it has come into general usage; it is also most descriptive, and the insect is not at all confined to apple or garden plants.

The black hunter is one of the most common and widely distributed predacious thrips in North America. As early as 1892 it was believed to be beneficial and miscellaneous reports concerning its apparent predacious habit have irregularly appeared. Nothing further has been contributed to its biology. Therefore, as a companion paper to that on *Scolothrips sexmaculatus* (Perg.) (JOUR. ECON. ENT. **32**(1): 43–47, 1939), the known facts concerning

L. mali are presented here as a contribution to our knowledge of beneficial insects.

ECONOMIC IMPORTANCE.—This insect is solitary in habit but very active. Even though it occurs in small numbers and has a very low reproductive capacity, it is of definite value in helping to curb both mite and thrips infestations.

Crawford (1909), Daniel (1904), and Moulton (1907) recorded *L. mali* feeding on scales. The writer has frequently observed the eggs and crawlers of the brown apricot scale (*Lecanium corni* Bouché) attacked by both adults and larvae. However, the black hunter appears to be of minor importance when compared with the parasites of the scale. Careful population studies would undoubtedly enable one to evaluate properly the relative importance of the scale predator. Fernald (1892), Jones (1935), and Plank (1936) considered this thrips to be predacious on lepidopterous eggs. Jones stated that 18 per cent of 122 peach twig borer eggs showed evidence of being preyed upon by *L. mali*. Our field observations indicate that on peaches the thrips chiefly seeks out and preys upon mites, red spider eggs, and thrips larvae. When unconfined, twig borer eggs are laid very irregularly on leaves, twigs and fruits and in small numbers. Therefore, they would not ordinarily supply a very great source of food for the thrips and would be encountered chiefly by chance. In contrast to predacious mites and internal parasites, *L. mali* plays a very minor part in controlling twig borer infestations of any proportions. Sharp (1938) states that "According to Mr. C. B. Nickels of the Bureau of Entomology and Plant Quarantine it is an important predator on the eggs of the pecan nut case bearer."

Where red spider infestations are well established, particularly web-spinning species, this thrips is largely replaced by *Scolothrips sexmaculatus*. On the other hand, the silver or russet mites (eriophyids) are preyed upon to a much greater extent by *L. mali* than *S. sexmaculatus*. As a matter of fact, the finding of the black hunter very often is the index of the presence of eriophyids even though they may be present in sufficiently small numbers to escape observation. The chief predator of *Calepitrimerus baileyi* Keifer, a silver mite on apple leaves, appears to be *L. mali*. In many instances observed at Davis, California, by late summer the mite appears to be almost completely controlled. Positive evidence of *L. mali* feeding upon the grape erinose mite, *Eriophyes vitis* (Landois) and the maple erinose mite, *E. ryderi* Banks has not been obtained but the activity of *L. mali* on such mite-infested leaves infers that its predacious habit is extended to these species also.

Colonies of the western flower thrips, *Frankliniella moultoni* Hood, and the grape thrips, *Drepanothrips reuteri* Uzel, in cages have been entirely eliminated by the black hunter. When unconfined, however, on vines and fruit trees, the predator appears to divide its activities among thrips, mites, and aphis nymphs. It has never been observed as a predator on onion, gladiolus, and bean thrips but is replaced by *Aeolothrips fasciatus* L. The reason for this is undoubtedly that in plowed fields where annual crops are grown suitable hibernating quarters are lacking. The pear thrips appears too early in the spring to be attacked by *L. mali*. When other economic species of thrips occur on trees and shrubs in major infestations in spring and early summer their reproductive capacity is so great in proportion to that of the predator that they are but little affected. Therefore, this thrips, while definitely predacious and beneficial is, in general, of minor importance.

BIOLOGY.—The life histories of very few predacious tubuliferous thrips have ever been worked out and so it is impossible to say whether or not that of *L. mali* is typical. Like the six-spotted thrips, *Scolothrips sexmaculatus* (Terebrantia: Thripidae) however, the entire life cycle of the black hunter is usually passed on the plants upon which it is found.

The life history data here given have been gathered at Davis, California, on apple trees during the past three years. The information is not entirely complete, but this thrips has proved to be one of the most difficult to rear that the writer has yet encountered. Both adults and larvae when confined in cages or vials were restless and intent upon escaping, even though a fresh supply of mite-infested leaves was made available.

Normally, on deciduous fruit trees, the adults (both sexes) are in hibernation from October to March. They find protection, and often cluster, under loose scales of bark, on the trunk and larger limbs of

the trees. Also, when such places are available, they are to be found in cracks in the limbs, curled leaves, old spider's webs, and commonly under the shells of old scale insects, particularly those that have been parasitized. Andre (1936) found adults hibernating in moss in Iowa. Watson (1913, 1918) reported this thrips active all year and the writer has found isolated adults only active on California laurel and toyon[1] during January. Mature larvae have not been found in the field after October 26; one pupa, however, was found as late as October 29.

In the spring the adults are frequently seen crawling about in the fruit buds and blossoms from the middle to the last of March. As the new leaves come out, adults are to be observed running about on them in the solitary manner which is their usual custom. The earliest that larvae have been collected is the last week in April. The first generation extends through May and the fore part of June. The larvae of the second generation appear during the latter part of June and early July. The period of greatest seasonal abundance of this thrips is during the second generation after which (during August and early September) there is a small scattered third generation. This condition is apparently the result of the decrease in the food supply or greater dispersion of the thrips seeking desirable colonies of mites on which to feed.

When the larvae are mature, they migrate by crawling from the leaves to suitable protected places on the host as described above for hibernation quarters. In some cases, the mature larvae migrate a long distance, from the tips of the outermost limbs on large apple trees down to the loose bark scales within three feet of the ground. On low shrubs and perennials, pupae may be found in curled leaves, and plant refuse on the ground surface. No cell or cocoon is made.

The reproductive potential is either very low or the black hunter has important natural enemies yet unobserved since very few young are produced. It is rare to find more than two larvae on the largest apple leaves heavily infested with eriophyid mites. Adult females, known to have mated, in cages in both field and laboratory have never given rise to more than one larva each (adult females, however, have been collected that had two eggs visible in the body cavity).

In the laboratory the length of the larval stage, in the few larvae which we have been able to rear, has varied from about 12 to 15 days. In every instance it was impossible to determine the exact day the new larvae appeared, but it is very doubtful that the larval stage will exceed 20 days. The prepupal stage varies from 2 to 3 days, the first pupal stage 1 to 2 days, and the second pupal stage 3 to 5 days. The total prepupal and pupal stage lasts 6 to 10 days. The length of the egg stage was not determined because of the extreme rarity of the eggs and the difficulty of locating them in the cages. The eggs are laid singly and apparently at random, chiefly on the lower leaf surfaces among the pubescence or in an angle of the larger veins. Individual adults have been kept alive for slightly over three weeks in cages. They doubtless live longer in the spring in the open and, of course, hibernating individuals survive for 4 to 5 months.

Both larvae and adults can survive for a short time on plant fluids alone. Individuals confined on apple leaves free of mites have lived as long as five days. Cannibalism has not been noted. The adults migrate by flying as well as by running. Flight is rarely observed except under very adverse conditions and unusually warm weather.

DISTRIBUTION.—The black hunter is apparently a native of North America but is also recorded from Panama, Barbados, Honduras, and Brazil. In North America, in addition to the United States, it is known from British Columbia and Ontario in Canada, and from Mexico. *L. mali* is one of the most common tubuliferae in the United States and has been collected in California, Connecticut, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Louisiana, Massachusetts, Maryland, Michigan, Missouri, Nevada, North Carolina, New York, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin, and Wyoming. In other words, it undoubtedly occurs throughout the United States. It is rather strange that this thrips has not been introduced in Europe and become established.

In California the black hunter is widely distributed and has been collected com-

[1] These plants are not deciduous.

monly from San Diego County to Lassen Park and from the ocean beach in Los Angeles County to Sonora Pass (9000 feet elevation). It is found in cultivated orchards as commonly as on native trees, shrubs, and flowers in their native habitat. The distribution of the thrips is apparently not regulated by any narrowly defined limitations of hosts or climate.

peach, pear, pecan, pine, *Plantago* sp., plum, prune, Russian thistle, sage, *Solanum*, sycamore, toyon, turnip, *Vinca major*, walnut, and willow.

The insects upon which *L. mali* has been observed to feed are: eggs of the brown apricot and black scales (and possibly those of yellow scale) and of peach twig borer, walnut aphis nymphs, and

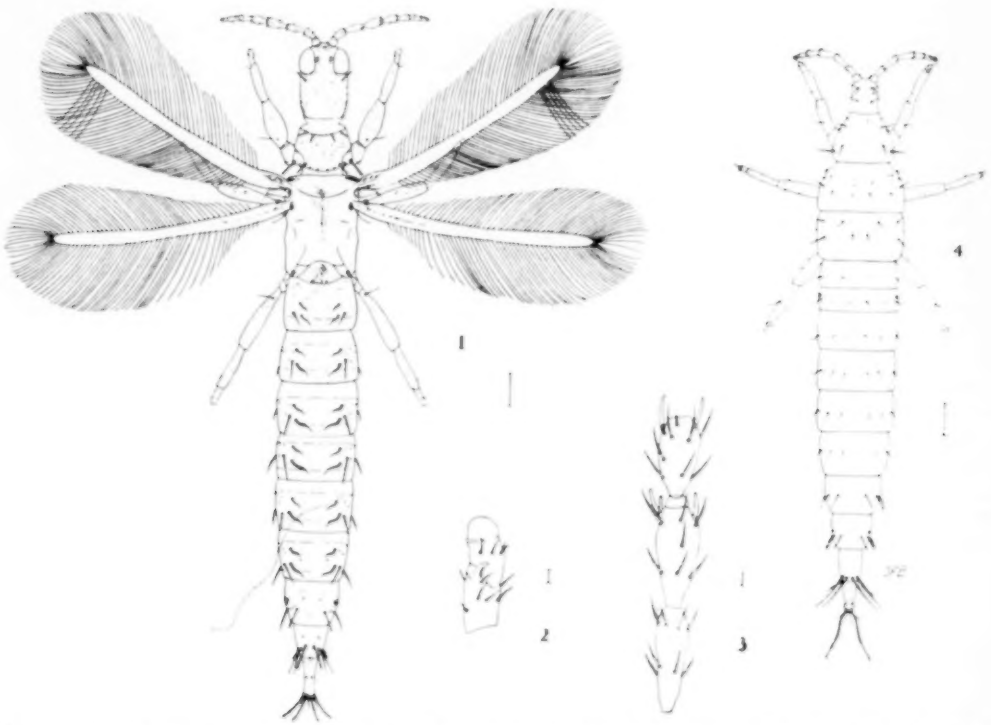

FIG. 1.—(Lines equal 0.1 mm. in 1 and 4; 0.01 mm. in 2 and 3) 1. Adult female of *Leptothrips mali* (Fitch); 2. Foretarsus of *Leptothrips mali* (Fitch); 3. Antennal segments III, IV, and V of adult of *L. mali* (Fitch); 4. Mature larva *L. mali* (Fitch).

HOSTS.—The plants on which this predacious thrips has been collected are as follows: *Acer glabrum*, alder, alfalfa, *Ambrosia*, *Amelanchier*, apricot, apple, *Artemesia tridentata*, ash, *Atriplex*, avocado, azalea, basswood, beans, birch, boxelder, *Cassia*, *Cedrus*, Sp., *Cercis canadensis*, chamise, cherry, chrysanthemum, citrus, coffee bean, corn, cotton, *Crataegus*, *Crotalaria*, dogwood, *Eriogonum* sp., fig, fir, *Fraxinus*, grape (cultivated and wild), grasses, Indian pipe, Indian tobacco, lupine, *Magnolia grandiflora*, *Malva*, maple, Spanish moss, miner's lettuce, morning glory, mule fat, mustard, nectarine, oak, adults and larvae of *Frankliniella moultoni* Hood and *Drepanothrips reuteri* Uzel in cages. This thrips also is a predator of the pecan nut case-bearer. Fernald (1892) thought that the black hunter was predacious on the eggs of the gypsy moth.

In addition to the above insects, this predator is known to feed on the eggs of the common red spider, *Tetranychus telarius* (L.), the brown almond mite, *Bryobia practiosa* Koch., and the mite *Calepitrimerus baileyi* Keifer.

TAXONOMIC POSITION.—*L. mali* belongs to a small genus, closely related to the large genus *Haplothrips* which is in-

cluded in the tubuliferous family Phlaeothripidae. The synonymy[2] of the black hunter is moderately involved. The other North American species of *Leptothrips* are *heliomanes*, *oribates*, *larreae*, *papago*, *acaciae*, and *oregonensis*, all described by Hood. Nothing is known concerning the biology of these species.

DESCRIPTION OF STAGES.—The adult of *L. mali* (Fig. 1—*1*) is slender, sharply pointed and metallic blue-black in color by reflected light. In length the adult female is about 1.5 to 1.75 mm. To the unaided eye the entire insect appears a uniform black with silvery-white wings. Under magnification (and transmitted light) a purple or reddish pigment can be seen distributed throughout the entire body. The dorsum of the head and the pronotum are cross-striate. The antennae are brown to yellowish brown with segment III the lightest, one small sensory cone on segment III, 3 cones on segment IV, and 2 cones on segment V (Fig. 1—*3*). (Some specimens differing in no other visible characters have 4 cones, two dorsal and two ventral, on the fourth segment (as does also *L. oregonensis* Hood). The hind margin of the fore wings has 3 to 8 accessory or intercalated bristles on the fringe near the tip. All tarsi have small, curved hooks or claws (Fig. 1—*2*), usually flattened against the side of the tarsus. A technical description of the adult can be found in Hinds' Monograph (pages 205–206) and the male genitalia have been illustrated by de Gryse & Treherne (1924).

The egg is translucent white, oval and about 0.481 mm. in length.

Newly emerged larvae are almost colorless but after feeding soon acquire a reddish orange pigment which in the second instar is a uniform maroon color. There are two tarsal hooks on all legs, together with a long, blunt bristle at the tip of each tarsus (in both larval instars). There are, however, distinct differences in the antennae and bristles by which the instars can be separated. The mature larva is illustrated in figure 1—*4*.

The pupal stages also are maroon in color with the appendages yellowish white. —1-6-40.

[2] Synonymy of *Leptothrips mali* (Fitch):
1855. *Phlaeothrips mali* Fitch.
1902. *Cryptothrips aspersus* Hinds.
1904. *Criptothrips californicus* Daniel.
1908. *Phyllothrips aspersus*, Hood.
1909. *Leptothrips aspersus*, Hood.
1910. *Liothrips meconnelli* D. L. Crawford.
1913. *Leptothrips aspersus macro-ocellatus* Watson.
1915. *Cryptothrips pini* Watson.
1920. *Haplothrips cassiae* Watson.
1921. *Cryptothrips adirondacks* Watson (in part).
1923. *Haplothrips pini*, Watson.
1923. *Zygothrips cassiae*, Watson.
Leptothrips russelli Morgan, 1913, is a synonym of *Haplothrips fasciculatus* (D. L. Crawford), 1909—see Hood, Pan-Pacific Ent. 3: 174, 1927.

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A Comparative Study of the Insect Food of Trout[1]

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Studies made on the insect fauna of northern and southern Michigan trout streams since 1933 have shown that certain characteristics of bottoms, temperatures, pH and other factors, determine the numbers and kinds of insects present. With this in mind, trout stomach analyses were made to determine the numbers and kinds of insects eaten by brook, brown and rainbow trout.

The data presented were obtained from the examination of 1,548 trout stomachs collected in both northern and southern Michigan trout streams. The principal objective of this investigation was a comparison of the numbers of insects eaten by the various species of trout.

The material for this investigation was collected from May 1 to the first week in October over the years 1933–1939 by fishermen. The method used in collecting the fish stomachs analyzed was to place labelled bottles along the streams at strategic points and depend upon fishermen to deposit the stomachs of their catches. This has been successful in most cases, and has enabled us to get a good cross-section of the insects consumed by trout in over 35 trout streams in northern and southern Michigan.

All of the stomachs collected were from trout seven inches to 23 inches in length. Of the total secured there were 888 brook trout, 290 brown trout and 368 rainbow trout. These stomachs were placed in a preservative as collected and their contents examined and determined later, in the laboratory.

Table 1 lists the insects found in brook trout stomachs along with the percentages of each.

According to this tabulation the largest number of insects were Trichoptera (caddice flies), Diptera (midges) and Hemiptera (corixids), but table 1 shows that other animals, mainly Crustacea and Mollusca, were second. This is unusual as on most of the streams from which the brook trout were taken either Ephemerida or Diptera were second in numbers but from one stream, Silver Creek in Allegan County, Southwestern Michigan, it was found that there were 1,139 caddice fly

Table 1.—Insects and other animals eaten by 888 brook trout.

	NUMBERS	PER CENT
Trichoptera	4,172	34.69
Other Animals	3,362	27.94
Diptera	1,312	10.90
Hemiptera	1,096	9.11
Ephemerida	824	6.86
Coleoptera	637	5.29
Hymenoptera	281	2.34
Plecoptera	111	.92
Odonata	76	.63
Neuroptera	44	.37
Orthoptera	43	.36
Lepidoptera	37	.31
Homoptera	21	.17
Unknown	13	.11
Total	12,031	

[1] Acknowledgment is due to the Fisheries Institute of the University of Michigan, Ann Arbor; the State Conservation Department; the Michigan Emergency Conservation Works, and grateful acknowledgment is due members of the Department of Entomology of Michigan State College.

[2] Michigan State College Experimental Station Journal Article No. 417, N.S.

larvae and 2,187 other animals, mainly Crustacea and Mollusca, in the stomachs of 179 brook trout. However, the waters of some southern Michigan streams are perhaps more suitable to Mollusca and Crustacea than others and this may explain the apparent discrepancy. All analyses of trout stomachs taken from northern streams showed either Diptera or Ephemerida second in numbers in brook trout stomachs. We have supported the stomach analyses by bottom samples taken monthly from northern and southern Michigan streams and found that molluscs and crustaceans are more abundant in some southern than in the northern streams.

Table 2.—Comparison of land and aquatic insects eaten by 414 brook trout.

	LAND INSECTS 19.14 PER CENT		AQUATIC INSECTS 80.86 PER CENT	
	No.	Per Cent	No.	Per Cent
Trichoptera	61	8.42	2,412	78.87
Ephemerida	96	13.26	400	13.08
Plecoptera	32	4.41	22	.72
Hemiptera	52	7.18	66	2.16
Coleoptera	150	20.73	40	1.31
Diptera	121	16.71	62	2.03
Neuroptera	0	0	25	.82
Odonata	7	.97	22	.72
Homoptera	11	1.52	0	
Orthoptera	19	2.62		
Hymenoptera	153	21.14		
Lepidoptera	18	2.49		
Other Animals	4	.55	9	.29
Totals	724		3,058	

In early analyses of fish stomachs from northern Michigan the insects were divided into land insects[3] and aquatic forms and in 414 stomachs analyzed (Table 2), 80.86 per cent were aquatic forms, while 19.14 per cent were land insects. Of the aquatic forms 78.87 per cent consisted of caddice flies while the land insects were made up of 21.14 per cent Hymenoptera (ants) and 20.73 per cent Coleoptera; Ephemerida adults and Diptera followed in order. At the present time we are trying to collect material from stomach analyses from October to May which should give us additional information as to the feeding habits of trout in Michigan during the colder months of the year.

[3] The term land insects includes both the normally terrestrial forms and the adults of aquatic forms.

Table 3.—Insects and other animals eaten by 290 brown trout.

	NUMBERS	PER CENT
Trichoptera	728	28.68
Ephemerida	678	26.71
Diptera	252	9.94
Odonata	212	8.36
Coleoptera	163	6.42
Other Animals	161	6.34
Hymenoptera	98	3.86
Plecoptera	93	3.66
Orthoptera	44	1.73
Hemiptera	39	1.54
Unknown	25	.99
Neuroptera	15	.59
Homoptera	14	.55
Lepidoptera	12	.47
Mecoptera	4	.16
Total	2,538	

Detailed in table 3, the 290 brown trout stomachs differ in contents from the brook trout stomachs in table 1 in that the relative numbers of Ephemerida and Trichoptera vary, but the analyses show that 28.68 per cent consisted of Trichoptera and 26.71 per cent Ephemerida. Diptera were third with 9.94 per cent. Of the total animals found in brown trout stomachs, 92.67 per cent are insects, whereas in brook trout only 72 per cent of the animals consumed consists of insects.

The comparison between land and aquatic insects eaten by 196 brown trout, shown in table 4, indicates that 30 per

Table 4.—Comparison of land and aquatic insects eaten by 196 brown trout.

	LAND INSECTS 29.50 PER CENT		AQUATIC INSECTS 70.50 PER CENT	
	No.	Per Cent	No.	Per Cent
Trichoptera	4	.74	547	42.47
Ephemerida	55	10.21	563	43.71
Plecoptera	29	5.38	51	3.96
Hemiptera	9	1.67	22	1.71
Coleoptera	89	16.51	14	1.09
Diptera	46	8.53	29	2.25
Neuroptera	5	.93	10	.78
Odonata	174	32.29	29	2.25
Homoptera	13	2.41	0	0
Orthoptera	31	5.75		
Hymenoptera	69	12.80		
Lepidoptera	9	1.67		
Mecoptera	4	.74		
Unknown and Other Animals	2	.37	23	1.78
Totals	539		1,288	

Table 5.—Insects and other animals eaten by 368 rainbow trout.

	Numbers	Per Cent
Trichoptera	792	33.76
Diptera	658	28.05
Ephemerida	351	14.96
Coleoptera	211	8.98
Hymenoptera	99	4.22
Other Animals	84	3.58
Plecoptera	53	2.26
Hemiptera	39	1.65
Odonata	22	.94
Unknown	21	.93
Neuroptera	6	.25
Orthoptera	4	.17
Homoptera	4	.17
Lepidoptera	2	.09
Total	2,346	

Note: No two stomachs corresponded in content. Algae and other aquatic plants were present in quantity but were not measured.

cent are land forms including Odonata (damsel flies), Ephemerida and Hymenoptera (ants and bees). Aquatic forms largely May fly nymphs and caddice fly larvae made up 75 per cent; in fact, 86 per cent of the aquatic insects eaten belong to these two groups. From table 4 it is also apparent that insects floating on the surface or dipping into the water fall prey to brown trout, especially damsel flies on the wing. Studies are being made of the insects eaten in winter by brown trout.

Table 5 shows that the insect food of rainbow trout closely resembles that of brook trout, although the analyses give the impression that this species of trout is a more general feeder than brook and brown trout. Examination of table 5 reveals that of the 368 rainbow trout stomachs analyzed 33.76 per cent of the total insect content was Trichoptera while 28.05 per cent was Diptera.

Of the land and aquatic insects eaten by rainbows as shown in table 6, we find that 31.88 per cent were land forms made up of five or six orders rather than two or three as in the case of brook and brown trout. This table also shows that fewer aquatic insects are eaten. In general, it may be said from a consideration of the analyses that the data are less conclusive than in the cases of brook and brown trout.

A summary of the insects consumed by the three species of trout in our Michigan streams, as evidenced by analyses of 1548 stomachs, indicates that certain kinds of insects are eaten in very large numbers by brook and brown trout, but that rainbows are more or less general feeders; also that the insects eaten are similar in our northern and southern streams.

A reconsideration of the tabular material brings into relief many other facts regarding the animals recovered from the trout stomachs. It is apparent, for example, that in the material examined insects far outnumbered all other animals; 71.95 per cent of the total in brook trout; 92.67 per cent in in brown trout; 95.49 per cent in rainbow trout. Dividing the insects from these 908 trout stomachs (Tables 2, 4, 6) into land and aquatic forms shows that a fairly large proportion of insects

Table 6.—Comparison of land and aquatic insects eaten by 298 rainbow trout.

	Land Insects 31.88 Per Cent		Aquatic Insects 68.12 Per Cent	
	No.	Per Cent	No.	Per Cent
Trichoptera	74	21.09	582	77.60
Ephemerida	110	31.35	52	6.93
Plecoptera	9	2.56	34	4.53
Hemiptera	10	2.85	8	1.08
Coleoptera	52	14.81	18	2.40
Diptera	5	1.42	24	3.20
Neuroptera	1	.28	3	.40
Odonata	3	.85	12	1.60
Homoptera	3	.85	0	
Orthoptera	2	.57		
Hymenoptera	76	21.65		
Lepidoptera	2	.57		
Other Animals	4	1.15	17	2.26
Totals	351		750	

eaten by trout is made up of land forms. Terrestrial species provided 19.14 per cent of the insects eaten by brook trout; 29.5 per cent of those found in the stomachs of brown trout, and 31.88 per cent of those recovered from rainbow trout stomachs. These facts indicate that insects are a most important fraction of the animals found in the trout stomachs examined.—1-6-40.

Pest-control officials of Alabama, Illinois, and Missouri, have revised their standardized quarantines on phony peach disease to remove from the regulated areas States and counties found eligible for release under the Federal-State survey for the disease in the field season 1939.

External Parasites of Sheep in Illinois: A Portable Dipping Vat

W. E. McCauley[1] and H. G. Russell[2]

For many years the literature dealing with animal parasites has contained many generalized statements relative to the distribution and abundance of external parasites of sheep. Lugger (1897) wrote of sheep parasitism in Minnesota "the sheep-tick is a veritable pest, especially in the spring on the younger animals. Sheep always kept in stables are almost free from such parasites, which seem to require conditions only found upon pasture." Niles (1897) said of parasites of sheep "the ticks are familiar parasites to almost every sheep owner. They are very prevalent in Iowa and are found wherever sheep are kept. The sheep-louse is plentiful on sheep coming in from Canada but is not mentioned as troublesome on our native sheep by our correspondents." Others as Niles (1900), Neuman (1907), Swingle (1913), Imes (1917), and Mote (1922) briefly mention the abundance of sheep-ticks where sheep are kept, usually stating that the open wool breeds are more susceptible than close wool breeds. In no case were the statements based upon specific investigation but rather upon information gathered from sheep raisers and shearing crews or from correspondence.

Survey of Parasites.—Because of this lack of concrete information regarding the prevalence of sheep parasites, especially in the corn belt states, the following survey was conducted. This work was made possible by cooperation with the Animal Husbandry Department of the University, the survey being conducted as a minor part of regularly scheduled extension meetings in the more important sheep-raising counties in the southern half of Illinois. The flocks examined were not selected for any particular reason except that the owners were active in the extension program of the College of Agriculture. Undoubtedly the average quality of sheep seen during this period would be somewhat better than that for the entire state, but strangely enough there was little if any correlation between the quality of sheep and the presence or absence of parasites particularly from the standpoint of purebreds vs. crossbreds. The examinations were made during the months of June and July. The map (Fig. 1) shows

Fig. 1.—Sheep parasite survey. Shaded areas indicate counties surveyed.

the counties in which examinations were made during the two years 1938 and 1939. There was much variation in the size of the flocks and only a few individuals were examined from any one flock. All cases reported are from breeding flocks, shipped-in feeder lambs not being considered in these figures as they represent another problem and in many instances have been dipped in transit so their condition would not be representative.

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Because of the obscurity of the breeding of many of the flocks examined, no attempt has been made to correlate the presence or absence of ticks with the breed. It can be stated, however, that the predominant breeds were Shropshire, Hampshire, and mixed western "white-faced" (probably Merino) strains. Other breeds seen were Southdowns, Dorset Horns, and Oxfords.

Lambs were chosen at random from each flock for examination as it was found that the freshly-shorn mature sheep were almost always free of ticks though the lambs in the same flock might carry dozens of parasites. Each lamb selected was carefully examined for lice and ticks, the short-wooled portions of the body receiving attention in all cases. Despite this attention to possible presence of lice only three flocks were found to be infested with these parasites and only one of the three was seriously infested. The biting lice, *Trichodectes ovis* L., were the only lice found, neither of the sucking forms being seen on any of the 90 flocks examined.

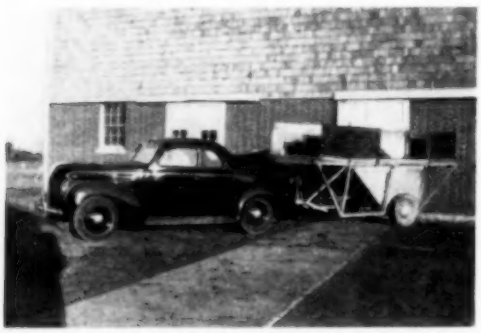

FIG. 2.—Portable dipping equipment in traveling position (note the front end gate removed to lower wind resistance).

The results of the survey indicate that the sheep tick or ked, *Melophagus ovinus* (L.), is by far the most important external parasite on farm flocks in Illinois. Of the 90 flocks seen only 18.9 per cent were found free of sheep ticks, 17.8 per cent had a light infestation, 28.9 per cent a moderate infestation, and 34.4 per cent were severely infested. The categories of light, moderate and severe were arbitrarily taken to indicate an average of less than five ticks per head as light, five to 20 ticks as moderate and 20 or more as severe. It was considered that in the case of either a moderate or a severe infestation the owner would be justified in dipping.

The relatively high percentage of farm flocks which were found infested is probably due to the laxity of flock owners in Illinois so far as dipping is concerned. In many instances abandoned dipping equipment was found rusting away, its use having been abandoned since sheep scab has ceased to be a major problem. It is felt that dipping for control of the sheep tick is certainly justified. It was to encourage community effort that the portable dipping equipment herein described was developed. This dipping vat and draining platform was used in dipping demonstrations as a part of the previously mentioned extension meetings. In some other states this project has proven quite valuable to the sheep industry.

PORTABLE DIPPING VAT.—The portable sheep dipping outfit (Fig. 2) was constructed at the University of Illinois by the Animal Husbandry Department at a cost of approximately $270 for materials and labor. Since this equipment was planned for use in demonstration work throughout the state, long hauls at fairly rapid speed were anticipated; construction, therefore, was more expensive than if the equipment had been for use within one community. State highway laws in Illinois require on trailer equipment of this weight a brake, numerous lighting effects, and a license. With the exception of the license these items might be overlooked on equipment which would probably be used only on local roads and in the daytime. To satisfy requirements for brake equipment a standard Plymouth axle and wheels were purchased along with a Bendix air brake, trailer hitch, fifth wheel, and jack from a trailer manufacturing company. These initial items were obtained at a cost of approximately $100.

It is estimated that for local use similar equipment without brakes and of somewhat less weight could be constructed at a cost of approximately $150.

An angle iron frame, electrically welded, was constructed on the axle. This frame was designed to support a platform 6 feet wide and 12½ feet long at a height 3½ feet above the axle so as to accommodate a dipping tank 3½ feet deep. The lower part of the frame, made of 3-inch angle iron, was 4½ feet wide on the axle and 7 feet long. The other parts of the frame

consisted of 2-inch angle iron braces extending upward and outward to support the platform frame. The axle was attached well toward the rear of the frame, throwing considerable weight forward, thereby adding traction to the automobile to which the trailer was attached.

The dipping tank, 7 feet long and 2 feet wide at the top, $3\frac{1}{2}$ feet deep, 3 feet long and 8 inches wide at the bottom, was mounted in the extreme left of the welded frame, the bottom of the tank resting on the lower part of the frame and the top flush with the top of the platform. This tank was made of sheet iron, electrically welded, with bars welded perpendicular at intervals on the outside to prevent bulging and breaking at the corners when the tank was charged with dip.

Fig. 3.—Dipping vat in use showing position of operators.

A draining floor of $5\frac{1}{2}$ inch tongue and groove material was bolted to the top of the welded frame, the front end of the floor being elevated $1\frac{1}{2}$ inches. Around the edge a 2 by 4 was bolted flat to the floor to hold excess dip on the platform. A 28-inch fence of light ply-board supported by $1\frac{1}{2}$ inch pipe welded to the top of the frame was constructed around the platform. The only openings were the 7-foot space at the left side of the dipping tank (Fig. 4) and the 2-foot space at the rear of the platform and directly behind the tank (see Fig. 5). A similar fence also separates the drain floor and the dipping tank (Fig. 4); a 3-foot continuation of this section, at the rear, was hinged to allow the sheep to pass from the drain floor into the chute (Fig. 5) through which they entered.

The chute, 2 feet wide and 9 feet long, was built of light wood with collapsible sides so as to accommodate itself to any angle between the platform and the ground. The chute has 32-inch sides, each supported by four uprights. It attaches to the platform by hooks at the bottom and the collapsible sides are held in place by iron rings which fit over the pipes supporting the platform fence.

Fig. 4.—Overhead view showing the drain-floor capacity and its relation to the vat.

Short pieces of 2 by 4 were bolted to the frame on the left side of the dipping tank, the free ends being attached to chains. These swing out and support a plank upon which the operator stands when the equipment is in use (Fig. 3). The sheep are driven up the chute to a small landing at the rear of the vat.

After arriving upon the platform from the chute, each animal is caught by the throat or by a foreleg, pulled into the dipping vat and held momentarily to insure thorough soaking. The head is then immersed, after which the sheep is allowed to go up a creep board to the drain floor. This floor will accommodate 25 to 30 lambs or 15 to 20 mature sheep (Fig. 4). Return of the excess dip to the vat was accomplished by making a "set" with the left wheel slightly lower than the right and adjusting the screw jack on the trailer so

Fig. 5.—Illustrating the dual purpose chute and swinging door which holds the dipped animals on the platform until sufficient draining has occurred.

as to cause the dip draining from the sheep to run forward. The upward slope at the front end of the platform directs the flow toward the vat.

The vat holds 150 gallons when filled to within 5 inches of the top. This amount of dip is sufficient for 75 to 100 ewes and lambs, especially if the ewes are in short fleece and are separated from the lambs so that they may be dipped first. The lambs, being smaller, can be immersed in less dip.

The advantages of this outfit over most others now in use are: that in most cases, dipping can be done without unhitching the trailer; the large drain floor accommodates more sheep, thus speeding up the operation; the 150-gallon tank is a convenient size for mixing most standard packages of dip; only one chute is used, compared with two on most other portable outfits; there is very little preparation necessary therefore a minimum of time for setting and reloading is required.

This equipment, loaded, weighs 1,770 pounds. For moving long distances the front and rear sections of the platform fence are removed or swung in line with the sides to lower wind resistance (Fig. 2).

Three men are sufficient to operate this outfit. Approach pens must be provided with a dividing gate to keep the dipped animals separate from the others. This did not prove troublesome as most farms have available a few portable gates which may be wired in proper positions. During the demonstration work as many as three flocks, totaling 350 head, were dipped in one day, in addition to other duties associated with extension meetings covering sheep management, marketing, and internal parasite control.

Much interest was displayed in the equipment, and it appears that several such vats may be in operation in Illinois within a year's time.—1-6-40.

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The Effects of Ingestion of Black Widow Spiders with Canned Food

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Rigid federal and state inspection has practically eliminated the inclusion of insects and insect parts from canned foods. Although the evidence is not convincing, several alleged cases of gastric disturbances have come to the attention of the authors, said to have been due to the presence of "black widow spiders" in canned foods.

A positive identification of spider parts (appendages) which came to hand, allegedly from canned spinach, could not be made, although these were reported to be from the "black widow." The accuracy of the identification was assumed and it seemed appropriate to conduct a series of tests to determine what possible ill effects might result from the ingestion of canned foods into which spiders had been put before subjecting the foods to the customary heat sterilization treatment.

Even though the spiders involved in the reported cases may not have been venomous species, it was decided nevertheless that tests should be made with our most venomous species, the "black widow," *Latrodectus mactans*. White mice, guinea pigs and a rhesus monkey were used as experimental animals, particularly the first because they are highly susceptible to black widow venom, the bite proving fatal in our experience in nearly 95 per cent of the cases. More than 60 per cent of the mice die within 60 hours after the bite; over 40 per cent between the 40th and 50th hours.

INGESTION OF RAW MACERATED VENOM SACS (June 7 to 14, 1939).—A. A pair of

venom sacs from a normal adult female black widow spider was macerated in 1 cc. of distilled water. At 2:07 P.M. 0.5 cc. of the mixture was given orally to a white mouse weighing 30.2 grams. No signs of discomfort or other symptoms followed, the mouse remaining normal to end of observation period. One hour after drinking the venom mixture, the mouse was placed on its normal diet; it ate with relish.

B. A pair of venom sacs from a normal adult female black widow spider was macerated in 1 cc. of normal saline. At 2:14 P.M. 0.25 cc. of the mixture was given orally to a mouse weighing 22.75 grams. The mouse showed no signs of discomfort after this treatment and was placed on normal diet one hour later. It remained normal to end of test period.

C. A third mouse weighed 20.5 grams, was given orally 0.25 cc. of saline-venom mixture and 0.5 cc. of the distilled water-venom mixture at 2:15 P.M. Placed on normal diet it remained normal to end of test period.

INOCULATED BOILED MACERATED WHOLE SPIDER. (June 13 to 14).—One adult black widow spider was boiled for eight minutes in 5 cc. of tap water. The spider was then macerated in the liquid in which it had been boiled and the supernatant fluid injected into two mice.

A. Weight of mouse 24.8 grams; received 0.5 cc. of fluid intraperitoneally at 11:13 A.M., June 13. Remained normal on normal diet to end of test period (June 14).

B. Weight of mouse 31.95 grams; received 0.25 cc. of fluid intraperitoneally at 11:43 A.M., June 13. Remained normal on normal diet to end of test period.

INGESTION OF BOILED WHOLE SPIDER. (June 9 to 14).—Two adult female black widow spiders were boiled for five minutes in 10 cc. of tap water. Mice fed, as follows:

A. Weight of mouse 20.2 grams; was allowed to eat one of the spiders; it remained normal to end of test period, June 14.

B. Weight of mouse 18.0 grams; drank 0.5 cc. of the liquid in which the spiders had been cooked and remained normal to end of test period.

C. Weight of mouse 14.9 grams; refused to drink the fluid in which the spiders had been boiled.

D. Weight of mouse 13.4 grams; drank 0.35 cc. of the liquid in which the spiders had been cooked and remained normal to end of test period.

E. Weight of mouse 13.2 grams; ate one of the spiders and remained normal to end of test period.

TESTS TO DETERMINE DISTRIBUTION OF VENOM IN THE BODY OF THE SPIDER.

A. Mouse inoculated intraperitoneally with 0.5 cc. of supernatant fluid obtained after macerating the *abdomen* of an adult female black widow spider in 1 cc. of distilled water. The mouse developed typical symptoms of black widow spider poisoning, although the symptoms were not severe. The mouse recovered.

B. Mouse inoculated intraperitoneally with 0.5 cc. of supernatant fluid obtained after macerating the abdomen of a second black widow spider in 1 cc. of distilled water. As in the other mouse, typical symptoms developed, also not severe, and the mouse recovered.

C. Mouse received intraperitoneally 0.5 cc. of the supernatant fluid resulting from the thorax (minus venom sacs) of an adult female black widow spider macerated in 1 cc. of distilled water. Mouse developed typical symptoms of spider poisoning; it recovered.

D. Mouse received intraperitoneally 0.5 cc. of the supernatant fluid resulting from the maceration of the thorax of an adult female black widow spider after the venom sacs had been removed in 1 cc. of distilled water. Again typical symptoms of black widow poisoning developed, and like the others the mouse recovered.

E. Mouse received subcutaneously 0.55 cc. of the supernatant fluid resulting from the maceration of a whole adult female black widow spider in 1 cc. of distilled water. The mouse died about 60 hours after the inoculation. Post mortem showed congestion of the lungs, serous sanguinous fluid in the peritoneal cavity and petechiae in the intestinal wall.

INGESTION OF BLACK WIDOW SPIDERS WITH CANNED SPINACH* (June 8 to 14).—1. A living adult female black widow spider was packed in the center of a can of spinach prior to sealing and cooking in a retort in the usual manner. When the can was opened the spider had taken on a

* In experiments 5 to 11 inclusive the spinach was subjected to the usual cannery process in the National Canners Association Research Laboratories in San Francisco.

deep reddish brown hue in place of the normal glossy black; it was very pliable. Net weight of contents of the can of spinach was 10.314 oz.; the drained weight was 8.915 oz.

A. Mouse weighing 28.45 grams ate, 1.10 grams of the spinach. Remained normal.

B. Mouse weighing 26.7 grams ate 0.5 grams of the spinach. Remained normal.

C. Mouse weighing 43.75 grams ate 0.3 grams of the spinach. Remained normal.

D. Mouse weighing 21.8 grams drank 0.75 cc. of the liquid from the spinach. Remained normal.

E. Mouse weighing 20.15 grams drank 0.75 cc. of the liquid from the spinach and then ate 1.2 grams of the spinach. Remained normal.

F. Mouse weighing 17.2 grams drank 0.5 cc. of the liquid from the spinach and then ate 1.5 grams of the spinach. Remained normal.

G. Mouse weighing 21.75 grams ate the entire spider cooked in the spinach. Remained normal.

H. Guinea pig weighing 295.8 grams ate 5.35 grams of the spinach. Remained normal.

2. A living adult female black widow spider was packed near the top of a can of spinach prior to sealing and cooking in retort. The net weight of the contents of the can was 10.225 oz. and the drained weight was 7.826 oz. (June 9 to 14).

A. Mouse weighing 20.7 grams ate 2.1 grams of the spinach. Remained normal.

B. Mouse weighing 17.75 grams ate 1.55 grams of the spinach. Remained normal.

C. Mouse weighing 21.3 grams ate 1.50 grams of the spinach.

D. Mouse weighing 16.3 grams drank 0.25 cc. of the spinach juice. Remained normal.

E. Mouse weighing 16.7 grams drank 0.75 cc. of the spinach juice. Remained normal.

F. Mouse weighing 14.8 grams drank 1.00 cc. of the spinach juice. Remained normal.

G. Mouse weighing 26.1 grams ate the entire spider. Remained normal.

H. Guinea pig weighing 756.1 grams te 11.70 grams of the spinach. Remained normal.

3. A gravid adult female black widow spider that had previously killed four white mice was placed in the center of the contents of a can of spinach prior to sealing and cooking in retort. On removal from the can the spider was intact and pliable as were the other spiders similarly treated, and the color had changed to sepia. The net weight of the contents of the can was 10.241 oz. and the drained weight of the spinach was 7.798 oz. (June 9 to 14).

A. Mouse weighing 19.6 grams ate 1.55 grams of the spinach. Mouse remained normal.

B. Mouse weighing 19.6 grams ate 0.95 grams of spinach. Remained normal.

C. Mouse weighing 24.4 grams drank 0.6 cc. of the liquid from the spinach. Remained normal.

D. Mouse weighing 21.8 grams drank 0.5 cc. of the liquid from the spinach. Remained normal.

E. Mouse weighing 15.1 grams drank 0.25 cc. of the spinach juice. Remained normal.

F. Mouse weighing 14.9 grams ate the entire spider that was canned with the spinach. Remained normal.

G. Mouse weighing 14.9 grams, was inoculated intraperitoneally with 0.5 cc. of the liquid from the spinach. The mouse remained normal.

H. Guinea pig weighing 704.0 grams ate 8.2 grams of spinach. The animal remained normal.

4. An adult female black widow spider that had died approximately four days previously was placed in the center of the pack of spinach prior to sealing and cooking. Upon opening the can the spider was found to be intact and pliable. The net weight of the contents of the can was 10.643 oz. and the drained weight of the spinach 7.901 oz. (June 10 to 14).

A. Mouse weighing 14.9 grams ate 0.3 grams of spinach. The temperature of this animal remained normal and there were no signs of distress.

B. Mouse weighing 16.55 grams ate 1.22 grams of the spinach. This animal remained normal as shown by general appearance and temperature readings.

C. Mouse weighing 13.4 grams ate 1.00 grams of spinach. Remained normal.

D. Mouse weighing 13.1 grams drank 0.75 cc. of the liquid from this can of spinach. Remained normal.

E. Mouse weighing 28.3 grams drank

0.6 cc. of the spinach juice. Remained normal.

F. Mouse weighing 22.75 grams drank 0.5 cc. of the spinach juice. Remained normal.

G. Mouse weighing 24.5 grams ate the entire spider packed in the can of spinach. Remained normal.

H. Mouse weighing 20.3 grams was inoculated subcutaneously with 0.5 cc. of the liquid from the spinach. Remained normal.

I. Guinea pig weighing 735.0 grams ate 15.65 grams of the spinach. The animal remained normal.

5. An adult female black widow spider, dead for six weeks, was placed in the center of a can of spinach before the spinach was cooked. The net weight of this can of spinach when opened was 10.203 oz. and the drained weight of the spinach 8.017 oz. When the spider was exposed by removing the top portion of the spinach in the can, it was found to be extremely friable. The legs had dropped from the body and were lying loose in the spinach. (June 10 to 14).

A. Mouse weighing 20.7 grams ate 2.7 grams of the spinach. Remained normal.

B. Mouse weighing 19.6 grams ate 1.2 grams of spinach. Remained normal.

C. Mouse weighing 21.8 grams ate 1.65 grams of the spinach. Remained normal.

D. Mouse weighing 18.75 grams drank 1.00 cc. of the liquid from the spinach. Remained normal.

E. Mouse weighing 16.0 grams drank 0.5 cc. of the liquid from the spinach. Remained normal.

F. Mouse weighing 19.5 grams drank 0.5 cc. of the liquid from the spinach. Remained normal.

G. Mouse weighing 21.48 grams ate the entire spider canned with the spinach. Remained normal.

H. Mouse weighing 24.1 grams was inoculated intraperitoneally with 0.5 cc. of the spinach liquid. Remained normal.

I. Guinea pig weighing 846.0 grams ate 9.25 grams of spinach. Remained normal.

OTHER EXPERIMENTS.—Three mice were fed spinach from a "control can," that is, a can of spinach in which there had been placed no spider. The net weight of the contents of the "control can" was 10.122 oz. and the drained weight of the spinach was 7.945 oz.

A. Mouse weighing 22.4 grams ate 1.15 grams of the spinach and has remained normal to date (June 14).

B. Mouse weighing 21.1 grams ate 1.4 grams of the spinach and has remained normal to date (June 14).

C. Mouse weighing 22.6 grams ate 1.20 grams of the spinach. Remained normal to date (June 14).

The can of spinach used in this experiment contained an adult female black widow spider packed in the center of the contents and was cooked in the retort.

The net weight of this can of spinach was 10.423 oz. and the drained weight of the spinach 7.460 oz. The spider canned in the spinach together with three living spiders that had been coarsely macerated were fed to a young monkey (June 12). The monkey showed no symptoms and remained normal.

DISCUSSION AND CONCLUSION.—That an object the color and size of a black widow spider could escape detection during the procedures immediately previous to actual canning may perhaps be admitted, although in the cases of alleged poisoning only spider appendages were offered as evidence for identification. Positive identification could not be made, but assuming that the customer's contention that it was a black widow spider was correct, the tests reported here were made with this species.

The bite of the black widow spider is followed by definite symptoms indicating a specific venom. Nearly 95 per cent of all white mice bitten by the spider in our laboratory die of arachnidism within two to three days; over 40 per cent die between the 40th and 50th hour.

Experiments performed by D'Amour et al. (1936) gave evidence of the extreme lability of the venom. Heating to 75 degrees C. for 20 minutes destroyed the toxicity. Heating to 37 degrees C. for 6 hours did not destroy the toxicity. Boiling the venom for 5 minutes destroyed its toxicity. Kellogg (1915) states that arachnolysin is wholly destroyed if exposed for 40 minutes to continuous heat of from 70 to 72 degrees C. It can, however, withstand a temperature of 56 degrees C. for 40 minutes. The first named authors showed that incubation of the venom at 37 degrees C. for 5 hours, in either a 2 per cent pepsin or 0.1 per cent hydrochloric acid solution destroyed the toxicity.

Tests made with white mice, guinea pigs and a monkey give evidence that ingestion of the venom, *i.e.*, eating black widow spiders, caused no harm to the experimental animals. Numerous tests made with experimental animals by allowing them to feed on canned spinach or drink liquid from canned spinach produced no ill effects which could be recognized by careful observation.—1-6-40.

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Some Factors in Natural Control of the Southern Pine Beetle, *Dendroctonus frontalis* Zimm.

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During the fall of 1938 a study was begun of the southern pine beetle in Gloucester County, Virginia. Examinations of the infested pine bark disclosed many dead larvae, and specimens were sent to Dr. J. G. Harrar, Plant Pathologist, Virginia Polytechnic Institute. Dr. Harrar reported that the larvae were infested with nematodes and later added that a pathogenic fungus had been recovered from a plate of the diseased material.

Table 1.—The mortality* of *Dendroctonus frontalis*, 1939.

Stage	Overwintering Brood		First Brood	
	Number of Insects Examined	Per Cent Dead	Number of Insects Examined	Per Cent Dead
Larva	3801	51.3	253	35.1
Pupa	413	2.6	227	5.7
Adult	60	8.3	227	0.0
Total	4274	46.0	707	14.4

* Exclusive of insect parasitism.

Steiner (1932) and Thorne (1935) described nemic parasites of the mountain pine beetle, *Dendroctonus monticolae* Hopk., but these parasites were of little importance in the natural control of the bark beetles during their studies.

MORTALITY OF *Dendroctonus frontalis*.—Examinations were made to determine the mortality of the bark beetles from natural causes, (table 1). It was found that 46 per cent of the overwintering brood and 14.4 per cent of the first brood were dead from causes other than parasitism by insects. Mortality was highest among larvae, being 51.3 per cent for the overwintering brood and 35.1 per cent for the first brood.

NEMATODES.—A study was begun to determine the percentage of the insects that were infested with nematodes. Microscopic examinations showed that 79 per cent of the dead and 37 per cent of the living insects of the overwintering brood were infested (see table 2). Bark containing overwintering brood was placed in the insectary, and 60 per cent of the adults that emerged were infested with nematodes. Nematodes were found in 68 per cent of the dead and in 27 per cent of the living individuals of the first brood in the field. They were found in 49 per cent of the first brood adults emerging in the insectary. Owing to the scarcity of these bark beetles during the second brood, no studies of this brood were made.

Specimens of the nematodes and adult beetles were submitted to Dr. G. Steiner, Principal Nematologist of the Bureau of Plant Industry, Washington, D. C. Dr. Steiner reports that two species of nematodes were found in the material submitted, both of which appear to be new species. One is a true endoparasite belonging to the genus *Anguillonema;* the other form, which belongs to the genus *Aphelenchoides*, appears to be only an associate of the bark beetles, the larval nematodes of this species attaching themselves beneath the elytra of the adult beetles for transportation purposes. Steiner plans to publish descriptions of these species.

MITES.—Rust (1933) reported predaceous mites as destroying eggs and young larvae of bark beetles, consequently they

should be considered in the natural control of these insects. Mites were found on the bodies of 17 per cent of the new adults of the overwintering brood and on 62 per cent of those of the first brood of *Dendroctonus frontalis* emerging in the insectary (table 2), but no information was obtained on their importance in the field. Specimens were determined by H. E. Ewing, Entomologist of the United States National Museum, as follows: two species of the family Parasitidae; one of the family Uropinae; one of the family Dameosmidae; and one of the family Cheltidae, genus *Cheltia*.

Table 2.—Results of examinations of *Dendroctonus frontalis*, 1939.

Item	Stage of Insect	Overwintering Brood		First Brood	
		Number Examined	Per Cent Infested	Number Examined	Per Cent Infested
Nematodes, dead insects*	Larva	190	80.5	69	65.2
	Pupa	9	44.4	13	84.6
	Adult	3	66.6	0	0.0
	Total	202	78.7	82	68.2
Nematodes, living insects	Larva	139	34.5	30	10.0
	Pupa	104	34.6	23	13.0
	Adult	29	58.6	187	31.5
	Total	272	37.1	240	27.0
Nematodes, insects in insectary	Adult (new)	86	60.4	342	49.4
Mites, insects in insectary	Adult (new)	1184	16.8	342	62.5
Insect parasites	All stages	4291	0.39	789	10.0

* Exclusive of those parasitized by insects.

INSECT PARASITES.—Insect parasitism of *Dendroctonus frontalis*, all stages, was 0.39 per cent for the overwintering brood and 10 per cent for the first brood. The following species of parasites, listed in order of their importance, were reared: *Coeloides pissodis*, Ashm.; *Cecidostiba dendroctoni*, Ashm.; *Spathius canadensis*, Ashm.; *Heydenia unica*, Cook & Davis; *Pachycerus ecoptogasteri*, Ratz.; and *Dendrosoter sulcatus*, Meus. Determinations were made by C. F. W. Muesbeck and A. B. Gahan.

DISCUSSION.—There are several factors to be considered in the subsiding of the epidemic of southern pine beetle while these studies were being made. The near normal rainfall undoubtedly had an effect on the vitality of the trees. Bird and insect predators of the bark beetles were abundant. Periods of mild weather during the winter months caused the emergence of many adult beetles which apparently were unable to attack trees at this season.

It is likely that the parasitic nematodes go through a free-living stage in the course of their development and must have moisture in the cambium tissues of the dying trees in order to make their way to the developing brood. The necessary amount of moisture in the bark tissues is dependent upon sufficient rainfall to soak the loosening bark. Such conditions existed in the infested area during the winter of 1938–39 and may have accounted for the high parasitism of the beetles by nematodes.

The information obtained does not warrant the conclusion that nematodes have been a major factor in controlling the epidemic of southern pine beetle; but this, together with other biological factors, is offered as one possible explanation of the sudden subsiding of the outbreak.

SUMMARY.—There was a high mortality of southern pine beetle in Eastern Virginia in 1939. Two species of nematodes were found infesting living and dead bark beetles of all stages. Five species of mites were found on the bodies of adult beetles in the insectary. Insect parasitism was negligible for the overwintering brood but amounted to 10 per cent for the first brood.—1-6-40.

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European Elm Bark Beetle and Dutch Elm Disease Control

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Shortly after the discovery of the Dutch elm disease, *Ceratostomella ulmi* (Schwarz) Buisman, in New Jersey, the writer voiced the opinion (Educational Bulletin 60, issued November 10, 1933) based on field examinations, that the control of the disease was largely a problem of controlling the beetle, *Scolytus multistriatus* Marsham, since the latter appeared to be the principal carrier of the infection. Subsequent developments have largely confirmed this finding and at the same time have enabled us to visualize more clearly the problem as a whole.

SIGNIFICANT HIGHLIGHTS.—The presence of the Dutch elm disease in the East was announced July 31, 1933, in a press release by the United States Department of Agriculture. Sixty-nine infected trees were found in Essex, Hudson and Passaic Counties, New Jersey. A release August 19 indicated that 309 trees had been located in New Jersey and that infected elms had been discovered on Staten Island, in three localities on western Long Island, and in Rye, Westchester County, N. Y. Before the year was ended, 740 diseased trees were known to occur in New Jersey, 77 in New York State, and 1 in Greenwich, Conn. The next year, namely 1934, 4,377 trees had been found in New Jersey, 2,427 in New York, and 55 in Connecticut (1 was at Old Lyme, some 100 miles east from the presumed center of distribution). It is evident there must have been an enormous production of beetles before such large numbers of infected trees were located and destroyed and this is confirmed by a statement from the Secretary of Agriculture of New Jersey dated September 27, 1934, to the effect that at that time there were still 2,000 infected elms standing in that state and constituting a menace to all surrounding areas.

BEETLE PRODUCTION AND DISTANT INFECTIONS.—A statement was made in a Dutch elm disease conference held November 16, 1938, to the effect that 600,000 elms in New Jersey had been treated with chemicals in the fall of 1936 and the spring of 1937 to kill the trees and prevent breeding of the bark beetles. The treatment failed to prevent the breeding of the insects which must have occurred largely in 1937. It is interesting to note that the following year there were over three times as many diseased trees found in New Jersey (it was nearly tenfold in Hunterdon County), namely the number jumped from 4,830 in 1937 to 16,248 in 1938. Furthermore, a survey showed numbers of infected elms in a band a mile wide around the chemically treated areas and that 75% of these trees were within the innermost half mile, indicating a rapid decline in the number of infected trees within a relatively short distance from the source of infection.

It is important to note that the conditions in certain parts of the infected area in 1933 and 1934 approximated closely those which obtained in 1937 and that in both cases relatively few diseased trees were located at a considerable distance from the centers of infection. Reference primarily is to the Old Lyme 1934 tree mentioned above and secondarily to the finding in 1938 and 1939 of a scattering, sparse distribution of diseased trees in Putnam, Dutchess and Ulster Counties, N. Y., some 75 miles from the area where there had been such a great production of European elm bark beetles in 1938 and also in the discovery in 1939 of a small number of diseased trees in Broome and Chenango Counties, over a hundred miles from this area of abundant beetle production.

WINDS CARRY INSECTS.—There has been a great reluctance to admit the possibility of an extended dispersal of beetles carrying the Dutch elm disease. It is more

than probable that this does not occur by beetle flight as ordinarily understood and yet it is within probabilities that such an extended distribution could occur and probably will occur in the future through wind drift; that is the involuntary transportation of beetles which have been raised to some height in the air by convectional currents and then carried at velocities which may run up to 75 or more miles an hour. It is easy to see with the foregoing in mind how a relatively extremely small percentage of beetles infected with the disease might be carried long distances and since this introduced beetle is considered to be the principal vector of the disease, one can hardly avoid being impressed by the factors cited above and the finding of diseased trees at great distances from previously known infected areas. We are here more concerned with the unusual distribution which results in a distant infection than the strictly local spread which occurs largely through the flight of the beetles, and is mostly limited to a distance of a half mile or a mile.

THE DISTRIBUTION PATTERN.—The writer has been much interested in wind drift and its effect on insect distribution for some 20 years. The finding of the infected tree at Old Lyme, Conn., in 1934 led him to suggest the probable carriage of the infection by drifting beetles. The theory did not meet with general approval and yet no more satisfactory explanation has been advanced. Nearly 5,000 gas-inflated toy balloons bearing tags requesting the finders to return them were liberated by the Bartlett Tree Research Laboratories from various localities in the affected area in 1936 and the distribution pattern was almost exactly that of the early spread of the Dutch elm disease along the north shore of Long Island sound. Balloon liberations were continued in 1937 and additional data indicated a similarity of distribution with some important additional details. Balloons were returned this latter year from Broome and Chenango Counties, N. Y., areas in which diseased trees were found the past season. There was another interesting phase, namely the return of 12 balloons from Rhode Island, from localities well distributed over that state and all from 88 to 115 miles from the point of release. This pattern of widely scattered sparse returns at a considerable distance from the point of origin appears to have been duplicated in large measure by the finding of diseased trees, mostly in small numbers, in 1938 and 1939 in all the townships of Putnam, Dutchess, and Orange Counties, N. Y., and in 11 townships or a city in Ulster County, N. Y. In other words, a general sparse distribution suggests a distant source of infection. The marked extension of the infected area recorded in New York State in 1938 and 1939 may have resulted from the enormous production of beetles from the 1936 and 1937 chemically treated trees in New Jersey.

CONTROL OF BEETLE AND DISEASE.—The European elm bark beetle breeds normally in sickly or diseased elm wood excepting possibly in places where there has been a tremendous production of beetles and they have been literally compelled to attack healthier tissues. A considerable number of diseased trees were located in a band one mile wide around the New Jersey areas where elms were treated in fall of 1936 and in the spring of 1937 with chemicals. The fact that seventy-five per cent of the infected trees were in the inner half mile of the band indicates a normal relatively short beetle flight and consequently a usually limited spread of the disease. Similar data have been obtained in New York State. Recently published figures show that federal and state authorities have spent over nineteen and one-quarter million dollars in an attempt to eradicate this insect, that over 56,000 diseased trees have been found in the eastern area and that the infected territory has increased in New Jersey since the end of 1934 from 1,402 to 3,413 square miles, in New York from 838 to 3,642 square miles and in Connecticut from 224 to 842 square miles, a total increase of from 2,464 to 7,897 square miles, an approximately three-fold extension. Evidently the writer's statement in 1934 to the effect that we must learn to live with the Dutch elm disease still holds. These figures indicate an inevitable spread with probabilities that by no means all of the infected trees in the eastern section have been located or will be located in the near future. It is doubtful if the large federal and state appropriations will be continued indefinitely, not to mention the probable need of greater sums necessary

for effective work in a continuously enlarging area. The question naturally arises as to what is to become of our elms?

The experience of the last six years indicates that the European elm bark beetle is mostly a local insect and that it limits itself largely to diseased or dying wood. The normal limit of flight suggests that ordinarily there would be no extensive or overwhelming invasion from nearby territory. The tremendous production of beetles in New Jersey in 1937 did not materially increase the number of diseased trees found in New York State in 1938. These data, while not conclusive, suggest possibilities for local control in cities and villages from two or possibly three midsummer relatively inexpensive prunings and the immediate burning of weak wood. Such a program should be thoroughly tested since it is entirely practicable in communities which take a pride in their elms. Others can hardly expect special consideration.

It is the writer's belief that ultimately most of the expense of protecting shade trees from Dutch elm disease and other troubles must fall upon the cities or villages and be mainly concerned with the elimination of sickly or diseased trees or parts of trees. This does not preclude assistance from Federal and State agencies. It localizes control and puts it on a more economical basis than heretofore. The results will be largely in proportion to local interest. The hickory bark beetle, the bronze birch borer, the two-lined chestnut borer, and the leopard moth are largely controlled by such procedure.

It does not require special training to detect, cut, and burn sickly or dying branches of trees. It may be made part of one operation. The Shade Tree Commissions, City Foresters, and Tree Wardens throughout the infected area have organizations qualified to do this work if granted the requisite funds, and other localities desirous of protecting their elms may take advantage of existing laws to provide the necessary organization. The prompt disposition of breeding material in most of the infected area is more important for local protection of trees than knowing the exact cause of the sickly or dying condition. Practically, there seems little advantage in the costly searching out and destroying the occasional diseased tree in a remote woodland area. Such trees are menaces in a distinctly minor degree to the valued elms on streets, in parks, and on private properties.—1-6-40.

The Value to Uninfested States of Gypsy Moth Control and Extermination

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Federal work in preventing the spread of the gypsy moth was begun in 1906 as a result of insistence by the New England States that Federal help be extended in combating this introduced pest. For 10 years prior to 1900 the state of Massachusetts had made an attempt, single handed, to exterminate the insect from the territory covering about 200 square miles around Boston. This work was discontinued as a result of apathy on the part of the public because the insect had been reduced so that no visible injury could be noted, the antagonism of certain elements who opposed it, and continued failure to finance the program adequately so as to assure eventual success. Subsequent experience in dealing with this insect clearly justifies the belief that if adequate financial support had been given and the work continued the infestation could have been entirely eradicated in this country. The tremendous increase and spread of the insect after the work was discontinued caused public demands for relief from unbearable conditions, and, after the state of Massachusetts had made appropriations aggregating $375,000 and passed a law requiring property owners to clear up infestation on their own premises, an appeal to the Federal Government was given favorable consideration and work was begun with the primary object of preventing the spread of the insect. To this end restrictions were placed on the movement of products likely to carry the pest, parasites and natural enemies were introduced from foreign countries, part of the expense being borne by the State of Massachusetts, and clean-up work along the principal

lines of travel out of the infested area was carried on for a number of years. The introduction and breeding of many species of parasites was continued, and they were colonized in the infested territory as rapidly as possible. In 1913, after the passage of the Federal Plant Quarantine Act, the infested territory was placed under Federal quarantine requiring the inspection and certification of products moving beyond the known infested area. By this time all the New England States were involved, but only a few infestations existed in Vermont and Connecticut. Federal field operations were confined to the outlying area, it being the policy of the States to confine their efforts to cleaning up the older infested territory.

A large amount of experimental work was conducted to improve the field methods which had been worked out in previous years by the State of Massachusetts. New facts were discovered in connection with the feeding habits of the insect, and advantage was taken of this information in connection with the removal of trees that were most susceptible to infestation and the encouragement of those species that were least attacked by the insect. Improvement in field methods and the development of high-pressure spraying resulted. Facts concerning the spread of the insect by the wind were determined, indicating that for the eastern part of New England the main drift of small caterpillars immediately after hatching was usually toward the north or northeast.

Progress on all this work was seriously curtailed during the period of the World War, and in 1922, owing to the finding of a few small infestations in New York just across the Massachusetts border, a conference was held at Albany, N. Y., attended by entomologists from all the states concerned, the Bureau of Entomology at Washington, and the Dominion Entomologist's office in Canada, to discuss the situation. It was decided that a control area, afterwards designated as a barrier zone, should be established, about 30 miles in width, extending from the Canadian border to Long Island Sound, and bounded on the west by the Hudson River. About one-half was located in New York and the remainder in western Vermont, Massachusetts, and Connecticut. The purpose was to keep this zone as free as possible from infestation, thereby preventing the westward spread of the insect. The work has been financed by the Federal Government, although the state of New York, through its own organization, takes care of most of the work in the zone within its own boundaries while the other states assume responsibility for the control in territory east of the zone.

In July, 1920, an infestation covering over 400 square miles had been found in northern New Jersey. Work was carried on as an extermination project in cooperation with the State Department of Agriculture, and in June 1932, after repeatedly scouting and treating all infestations in the original and surrounding area embracing over 2,300 square miles, the Bureau of Entomology discontinued operations. Work has been carried on since that time by a small force employed by the state. A small infestation was found in 1933. This has been cleaned up, and no infestation has been found in the state since 1935.

Another serious infestation was found in northeastern Pennsylvania in 1932, and work in cooperation with the Bureau of Plant Industry of that State has been under way since that time. No defoliation has resulted since the year of discovery. The area under state quarantine is approximately 1,000 square miles, and a surrounding area of 1,500 square miles will require additional inspection as the work of exterminating the insect proceeds from the outer rim toward the center of the original infestation.

Since the barrier zone was established, small colonies have been found on Long Island, in the Bronx in New York City, and at several points adjoining or directly west of the zone. Most of these have been exterminated, while in others the work is nearing completion.

The original barrier zone contained 9,400 square miles. Since it was established a number of areas have been added east of the original zone, embracing 1,500 square miles in Vermont and Connecticut, making a total of 10,900 square miles. Areas on the west side of the zone, particularly in northern New York, Vermont, and southern Connecticut, have been found free from infestation, and periodic inspections have been discontinued.

Prior to the discovery of the heavy infestation in Pennsylvania in 1932, regular funds required for this work were reduced 37 per cent and they have never been in-

creased. Beginning in 1934, emergency funds were allotted for use on Federal gypsy moth projects in all the New England States, New York, New Jersey, and Pennsylvania.

Protective work has been done between the Connecticut River and the barrier zone in Vermont, Massachusetts, and Connecticut by W.P.A. labor and by details from C.C.C. camps, and this combined work has reduced many serious infestations during this period.

For 16 years the maintenance of this zone and the clean-up of outlying infestations have prevented general westward spread of the insect and have eliminated the necessity for the states, aside from those now affected, to spend funds for its control or to suffer loss of trees or injury due to defoliation. The entire cost to the Federal Government from regular and emergency funds for 33 years of operation has averaged less than $700,000 per year, and the cost to infested states to maintain partial control of the insect has averaged over $1,000,000 annually. If the idea that "an ounce of prevention is worth a pound of cure" is sound, then the funds which have been expended by the Federal Government for protecting the rest of the United States from this insect have paid large dividends.

Briefly stated, the present situation is serious, and if other sections of the United States wish to receive the protection which has been given them in the past, these facts should be considered carefully. Since 1934 most of the personnel used on gypsy moth work, aside from general or district supervision, has been supplied from relief rolls. Since 1936, when the number of these employees reached more than 5,000, the force has been decreased progressively until this year, when fewer than 800 are employed. This force consists not only of laborers who for the most part are competent, under supervision, to do the work to which they are assigned, but also includes scouts who do inspection work to find infestations and the foremen of crews who direct this work under general supervision. The regular supervisory force has faced a tremendous task to train relief men for this work, particularly because there has been a heavy turn-over in employees. This force is not mobile, as the men are required to work locally. In many sections of the territory, particularly in the large forested areas where most of the work is done, there is a very sparse population, and it is impossible to cover all the territory that should be examined on account of the location of the personnel.

During the last few years infestation has built up, and large areas have been defoliated directly east of the Connecticut River, except in the State of Connecticut, and similar areas have developed during the last two years between the Connecticut River and the barrier zone in Vermont, Massachusetts, and Connecticut in spite of the fact that all the force available has been utilized in these States.

During the last two or three seasons there has been some wind spread of small caterpillars into the zone. This is indicated by a considerable number of single egg-cluster infestations. Since the eggs were deposited in July 1939 some scouting has been done in the zone, and unusually large numbers of single egg-cluster infestations have been found in towns in Vermont, Massachusetts, and Connecticut and a smaller number in the New York section of the zone. In addition to favorable conditions for wind spread, it is now evident that the hurricane which swept through New England in September, 1938, has contributed to the spread of the insect to a far greater extent than was appreciated at the time. While the amount of timber that was blown down or uprooted in and near the zone was not so great as in many sections east of the Connecticut River, it is apparent, from the general course of this tremendous wind storm, that egg clusters must have spread into the zone area, to some extent at least, on leaves, bark, or other material, and that this is a contributing factor in bringing about the condition that has been found during the last few months.

Normal employment has increased in much of the territory, particularly in the industrial and manufacturing sections of the zone area. It is now impossible to secure W.P.A. labor in some sections, and as the expenditures that can be made for all non-labor purposes under W.P.A. funds are based on man-months of labor performed, the volume of work is reduced, and sufficient equipment or supplies cannot be procured.

This project has been able to utilize unemployed labor during the emergency through which the country has been pass-

ing, but it is clear that, unless thorough work is done in the sections where it is urgently needed, including the small infestations in the zone, the zone which was created to serve as a barrier and the exterminative work which is being carried on in northeastern Pennsylvania, the most westerly infestation known in the United States, will fail to protect the rest of the country.

It would seem that the states which have been protected for many years should interest themselves in this project if they desire a continuance of this protection. As a matter of conservation and good economics it would seem desirable to keep this insect in the territory where it is now established, so that other sections of the country will not have just another pest to fight.—1-6-40.

Notes on *Oncideres* Twig Girdlers

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The *Oncideres* twig girlers have long attracted the attention of the economic entomologist as a result of their injury to broadleaved trees, including those grown for fruit, nut, shade and ornamental purposes. Unfortunately, however, the species have been commonly confused and the literature on the group is so full of misidentifications that it cannot be satisfactorily used at present by the general entomologist. In an attempt to clarify some of the existing confusion, the following notes are offered on the most important economic species in the United States.

The HUISACHE GIRDLER, *Oncideres pustulata* Lec.

Oncideres pustulata Lec., 1854, Proc. Acad. Nat. Sci. Phila., **7:** 82 (descr.); Horn, 1885, Trans. Am. Ent. Soc., **12:** 142 (key); Hamilton, 1896, Trans. Am. Ent. Soc., **23:** 140 (key); Schaeffer, 1906, Can. Ent. **38:** 19 (key); Linsley and Martin, 1933, Ent. News, **44:** 183 (habits).

Oncideres putator, High (nec Thomson), 1915, U. S. D. Agr., Bul. 184, pp. 1–9, pl. 1–4 (biol., control); Craighead, 1923, Can. Dept. Agr., Bul. 27 (n.s.), p. 132 (larva, hosts).

Oncideres trinodatus, Essig (nec Casey), 1926, Ins. of West. N. Am., p. 460.

This is one of the two species which appear in economic literature under the name "*putator* Thomson." High (1915) has given an excellent account of its habits under that name but most of the published records to which he refers pertain to *rhodosticta* Bates. The species is abundant in the Lower Rio Grande Valley of Texas and, unlike most of our species which confine their attacks to twigs, *pustulata* girdles branches ranging from 20 to 40 mm. in diameter. Its favored hosts are *Acacia farnesiana* and *Pithecolobium flexicaulis*, but *Prosopus glandulosa*, *Acacia berlandieri*, *Parkinsonia aculeata* and *Mimosa lindheimeri* have also been recorded. Many other wood-boring insects avail themselves of the branches freshly cut by this species, among which are the following roundheaded borers which have been reared by the writer: *Achryson surinamum* (L.), *A. concolor* Lec., *Anoplium truncatum* Lec., *Ibidion exclamationis* Thoms., *I. townsendi* Linell, *Obrium maculatum* (Oliv.), *Placosternus difficilis* (Chev.), *Euderces exilis* Casey, *Ecyrus texanus* Schffr., *Leiopus wiltii* Horn, *L. houstoni* Casey, and *L. texana* Casey.

The TWIG GIRDLER, *Oncideres cingulata* (Say)

Saperda cingulata Say, 1826, Jour. Acad. Nat Sci. Phila., **5:** 272.

Oncideres cingulata, Haldeman, 1847, Trans. Am. Philos. Soc., (2) **10:** 52 (habits); LeConte, 1852, Jour. Acad. Nat. Sci. Phila., (2) **2:** 165 (descr.); Walsh & Riley, 1868, Am. Ent., **1:** 76–77, f. 66 (habits); Riley, 1880, Am. Ent., **3:** 297, f. 155–56 (habits, hosts); Horn, 1885, Trans. Am. Ent. Soc., **12:** 195 (descr.); Hubbard, 1885, Ins. aff. Orange, pp. 128–29, f. 49–50 (habits, hosts); Packard, 1890, 5th Rep. U. S. Ent. Com., pp. 288–89, f. 113–14 (habits, hosts); Scheffer, 1895, Insect Life, **7:** 345 (habits); Felt, 1905, N. Y. State Mus., Mem. 8, **1:** 271–74 (biol.); Schaeffer, 1906, Can. Ent., **38:** 19 (key); Gill, 1917, U. S. Dept. Agr., Farm. Bul. **843:** 42–47, f. 53–57 (biol., control); Craighead, 1923, Can. Dept. Agr., Bul. 27 (n.s.) p. 131, pls. 2, 13, 31, 32 (larva, hosts); Leiby, 1925, Bul. N. C. Dept. Agr., **1925:** 52–56, f. 50–54 (biol., control); Moznette, Bissell, and Adair, 1931, U. S. Dept. Agr., Farm. Bul., **1654:** 49–53, f. 62–66 (biol., control).

Oncideres texana, Herrick (nec Horn), 1902, Jour. N. Y. Ent. Soc., **10:** 15 (biol.); Herrick, 1904, Miss. Agr. Exp. Sta., Bul. **86:** 3–10, f. 1–5 (biol., control); Girault, 1910, Ent. News, **21:** 226–28 (ovipos.); Bilsing, 1916, Jour. Econ. Ent., **9:** 110–15 (biol.).

Oncideres cingulatus pallescens Casey, 1913, Mem. Coleopt., **4:** 353, *n. syn.*

Oncideres praecidens Casey, 1913, Mem. Coleopt., **4:** 354, *n. syn.*

This species is most important as a pest of hickory, pecan and persimmon but also injures elm, poplar, sour-gum, basswood, honey locust, dogwood, apple, pear, peach, plum, citrus, eucalyptus and probably many other trees. It appears in the literature under the common names of "Banded Saperda," "Hickory Twig Girdler" and "Pecan Twig Girdler." As a pest of pecan it has been incorrectly referred to as "*Oncideres texana* Horn."*

The TEXAS TWIG GIRDLER, *Oncideres texana* Horn

Oncideres texana Horn, 1885, Trans. Am. Ent. Soc., **12:** 195 (descr.); Hamilton, 1896, Trans. Am. Ent. Soc., **23:** 140 (key); Schaeffer, 1906, Can. Ent., **38:** 19 (key); Casey, 1913, Mem. Coleopt., **4:** 353 (descr.); Linsley and Martin, 1933, Ent. News, **44:** 183 (habits).

Oncideres subtropicus Casey, 1913, Mem. Coleopt., **4:** 353 (descr.) *n. syn.*

As mentioned above, the species which appears in economic literature under the name "*texana* Horn" is the twig girdler, *Oncideres cingulata* (Say). The present species is closely related but differs by the presence of acute lateral pronotal tubercles, a dark brown integument, and broad, white, elytral fasciae. It occurs in southern Texas where it girdles the twigs of *Acacia* and probably also *Prosopis* and *Pithecolobium*. As is frequently the case in this genus, the freshly cut twigs are utilized by numerous other insects. The following roundheaded borers have been reared from twigs girdled by this species: *Obrium maculatum* (Oliv.), *Sphaenotheeus bivittatus* Dup., *Leiopus wiltii* Horn, *L. texana* Casey, *L. houstoni* Casey, *and Ataxia crypta* (Say).

The ARIZONA OAK GIRDLER, *Oncideres quercus* Skinner

Oncideres quercus Skinner, 1905, Ent. News, **16:** 291 (descr., habits); Schaeffer, 1906, Can. Ent., **38:** 19 (key); Beyer, 1908, Jour. N. Y. Ent. Soc., **16:** 32 (habits); Casey, 1913, Mem. Coleopt., **4:** 352 (descr.); Brisley and Channel, 1924, Jour. Econ. Ent., **17:** 159 (habits); Essig, 1926, Ins. of West. N. Am., p. 460.

This species is closely related to *cingulata* and *texana* but is more slender with the elytra densely clothed with cinereous pubescence. It occurs in southern Arizona and girdles oak branches about one-half inch in diameter. The writer has observed the species seriously affecting the oaks in the Huachuca Mts. (Carr and Miller Canyons), where the ground beneath oak trees may be literally covered with girdled twigs in the fall. Beyer (1908) reports that a scolytid beetle, *Chramesus*, and a roundheaded borer, *Poliaenus negundo* Schffr., commonly breed in the girdled branches.

The MESQUITE GIRDLER, *Oncideres rhodosticta* Bates

Oncideres rhodosticta Bates, 1885, Biol. Centr.-Amer., Coleopt., **5:** 367 (descr.).

Oncideres putator, Horn (nec Thomson), 1885, Trans. Am. Ent. Soc., **12:** 195 (key, distr.); Howard, 1900, U. S. Dept. Agr., Div. Ent., Bul. 22 (n.s.), p. 94 (injury); Schaeffer, 1906, Can. Ent., **38:** 19 (key).

Oncideres cingulatus, Hamilton (nec Say), 1896, Trans. Am. Ent. Soc., **23:** 141 (pars).

Oncideres trinodata Casey, 1913, Mem. Coleopt., **4:** 352 (descr.), *n. syn.*

Oncideres sp., Craighead, 1923, Can. Dept. Agr., Bul. 17 (n.s.), p. 132 (larva, hosts).

Oncideres pustulatus, Essig (nec LeConte), 1926, Ins. of West. No. Am., p. 460. f. 368 (habits, distr.).

The confusion that exists in the literature regarding this species dates from a misidentification by Dr. George Horn (1885) who first recorded it from the United States (as "*putator* Thoms."). Hamilton (1896) increased the confusion by regarding the species as identical with the common *cingulata* and merging its records with those of that species. This error was corrected by Schaeffer (1910) who resurrected for it the name "*putator*." Casey (1913) recognized that the species was distinct from the true "*putator*" of Thomson and described it as new under the name *trinodata*. Actually, however, it should be known as *rhodosticta* Bates, which was described from Lerdo, Mexico, in 1885. It may be readily distinguished from the other species in our fauna by the presence of three callosities in a transverse row on the pronotum, the pale ante-median fascia of the elytra, and the yellowish or tawny spots with which the pubescence of the elytra is variegated. It occurs in southwestern United States and northern Mexico and girdles small branches of mesquite (*Prosopis*). Craighead has also recorded what appears to be this species from *Sarcobatus*. Essig (1926) has illustrated the adults and their injury under the name "*pustulatus* Lec." —1-6-40.

* The synonymy of the two forms named by Casey was very kindly confirmed by Mr. W. S. Fisher.

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Studies of Mosquito Repellents, I. Test Procedure and Method of Evaluating Test Data[1]

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In a search for chemicals possessing mosquito repellent properties, started in 1935,* a large number of organic compounds were tested in addition to available proprietary products and repellents recommended by various investigators from time to time. It is the purpose of this paper to deal with the procedure used in testing and to describe the method of evaluating test results. A subsequent paper will present experimental data and show the relative effectiveness of a number of the materials tested.

TEST PROCEDURE.—A practical method of testing was adopted, that is, one which would be directly comparable to conditions of normal usage. Tests are carried out in the field by first exposing an untreated arm to the elbow or a leg to the knee to bites of the insects for a definite period, usually two minutes. The rate of biting per minute thus determined indicates the insect activity at the time of the test. A measured quantity of the chemical to be tested, about 1 cc. for the arm and 2 cc. for the leg, is then applied to the corresponding arm or leg. Treated arm or leg is exposed continually to insect activity during the period of the test, while untreated portions are exposed for two minute check counts at intervals of fifteen minutes or a half hour. An average of these check determinations is made at the end of the test and the average number of bites per minute on untreated area is called the "biting frequency" during the test period. The time in minutes required to obtain the first bite on the treated area is called the "repellent time." Most of the tests were made against salt marsh mosquitoes, mainly *Aedes sollicitans* and *Aedes cantator*.

METHOD OF EVALUATING RESULTS.—The time during which a repellent affords protection to the user is the customary measure of its effectiveness. If comparative trials of repellents could be made under similar conditions of environment and biting frequency, little trouble would be experienced in evaluating the results. In the field the various influencing factors are constantly changing, causing the repellent time to fluctuate in turn. To obtain repellent data for all influencing conditions would require extensive testing of each substance for which repellent knowledge was sought. In a previous publication (Granett, 1938) it has been pointed out that various environmental

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[1] Early publication of this paper and the one which follows has been secured by payment of the costs of printing.

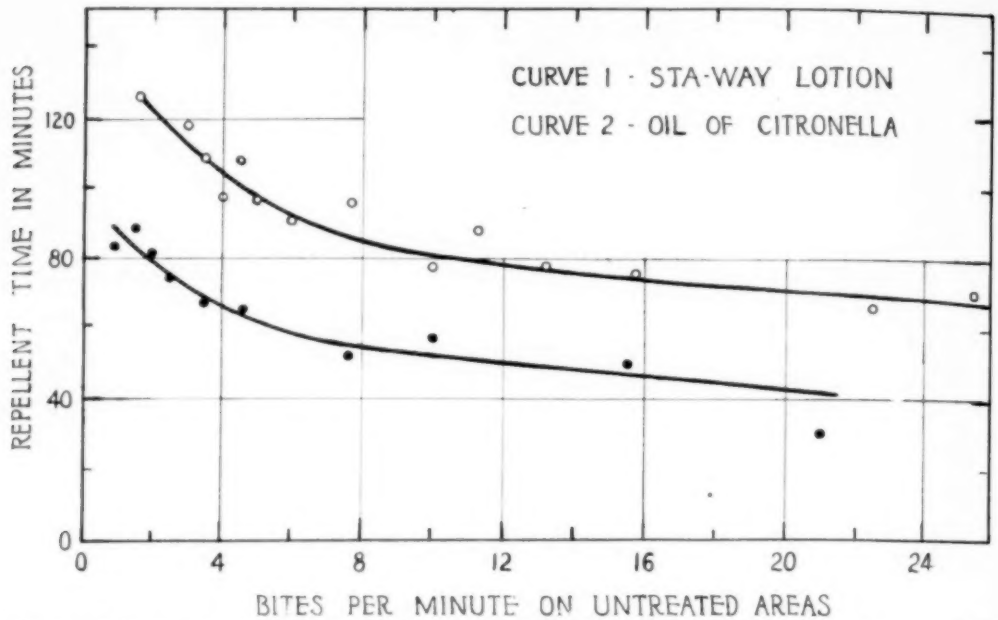

FIG. 1.—Relation between biting frequency and the repellent time afforded by *Sta-Way Lotion* and oil of citronella. Each circle represents an average of 2 to 7 tests.

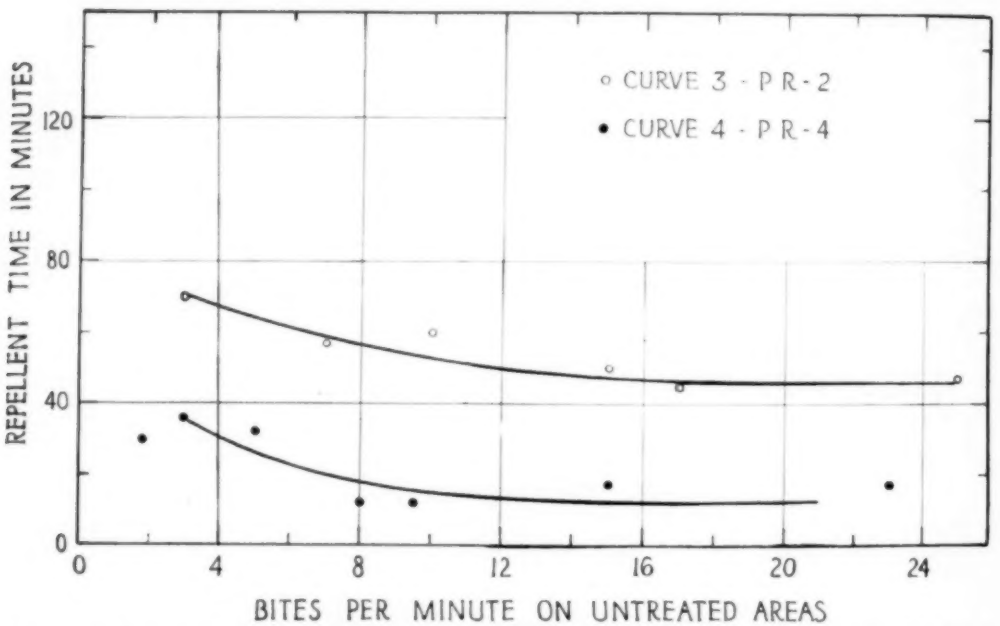

FIG. 2.—Relation between biting frequency and repellent time afforded by two proprietary repellents, PR2 and PR4. Each circle represents an average 1 to 3 tests.

and physiological factors present at the time of the test exert an influence on the insects, and that the influence is reflected by the rate of biting on untreated areas. With an increase in biting frequency as indicated by a greater biting rate on the untreated areas, there is a decrease in repellent time.

The nature of this relationship is illustrated by results of fairly extensive tests

with four repellents of widely differing chemical composition. They are a new repellent, developed during this investigation and now known under the brand name of "*Sta-Way Insect Repellent Lotion*,"* oil of citronella, and two proprietary repellents whose composition is known to us.

The data from these tests is shown in the form of curves in figures 1 and 2.

The shape of these curves shows that the decrease in repellent time is not directly proportional to the increase in biting rate. At the lower biting rate ranges, from one to ten per minute, there is a marked drop in repellent time with each increase in biting frequency. At higher biting rates, the slope of the curve levels off and the decrease in repellent time is relatively slight. Ten bites per minute is approximately the point at which this change occurs.

If we know the repellent time of a product at only one biting rate we can make a significant comparison of it with any other substance the repellent time of which is known at the same biting rate. A comparison at any single biting rate is naturally less significant when the two repellents are nearly equal in performance. However, when we use *Sta-Way Lotion* as our reference standard its performance is so far above those with which it is compared that the results are of adequate significance.

A study of the curves shows that for any given pair of repellents, the ratio of repellent times at a given biting rate is approximately constant throughout the entire biting range. This information makes it unnecessary to test compounds of unknown repellency at more than one or two biting rates, provided check tests are in reasonable agreement at these rates.

We have rated the repellent performance of all products in terms of that of *Sta-Way Lotion* and call this comparative value the "repellent rating" of the material. This rating is the repellent time of the compared product divided by the repellent time of *Sta-Way Lotion* obtained at the same biting frequency. For example: if the repellent time of the compared product is 52 minutes with a biting level of 4 bites per minute, while the repellent time of *Sta-Way Lotion* is 104 minutes at the 4 bite per minute level, then the repellent rating of the compared material is 50 per cent.

If the compared product is tested at several biting levels, the separate values are calculated for the repellent rating at each biting level. The average of these values gives the average repellent rating for the product over the range of biting frequencies involved.

* Active ingredients are diethylene glycol monobutyl ether acetate and diethylene glycol monoethyl ether.

SUMMARY.—A method of testing mosquito repellents in the field comparable to normal use of such materials is described.

Application of the test material is made to one arm or leg of the tester. The protection afforded by a repellent is determined by the time in minutes to the first bite on these treated areas and is designated as the repellent time of the material under test. Determination is also made of the insect biting frequency during the test as indicated by observation of the bites per minute on corresponding untreated areas.

It is found that with an increase in biting rate there is a decrease in repellent time. Curves are presented which show this relationship for four repellents. For any given pair of repellents the ratio of repellent time at a given biting rate is approximately constant throughout the entire biting range.

For comparative purposes a product developed during the repellent investigation is used as a reference standard. The "repellent rating" of any given material is determined by dividing its repellent time by the repellent time of the reference standard obtained at the same biting rate as the compared material.

If the compared product is tested at several biting levels, the repellent ratings at the different levels are averaged to give a single comparative value.—4-16-40.

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Studies of Mosquito Repellents, II. Relative Performance of Certain Chemicals and Commercially Available Mixtures as Mosquito Repellents

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Despite the fact that organized mosquito control work has advanced steadily, satisfactory elimination of mosquito annoyance is still restricted to relatively small areas. Large numbers of people are still exposed to periodic attack by mosquitoes and other blood-sucking pests and it seems safe to assume that such annoyance will continue for many years to come. As a means of discouraging biting by these pests, people have frequently resorted to repellents of one kind or another. J. B. Smith (1901) was one of the first to report on the effectiveness of oil of citronella, now widely known as a repellent. Prior to that time, and since, many other essential oils, mixtures of various kinds of oils, greases, ointments, and powders have been tried wtih varying degrees of success. Bishopp (1939) still recommends oil of citronella or a mixture of citronella and pennyroyal. Bacot and Talbot (1919) using a laboratory method of testing, studied various mixtures of essential oils. Bunker and Hirshfelder (1925) made a rather thorough investigation of a number of chemicals and listed twenty most effective, the first six of which were citronellol, caprylic alcohol, benzyl alcohol, geranyl acetate, linalyl acetate and amyl salicylate. Mail (1934), taking a lead from Bunker and Hirschfelder's work, made and tested some derivatives of salicylic acid. He found them to be fairly effective against *Aedes* species of mosquitoes in Montana although some of the better compounds were irritating to the skin. Rudolfs (1930), in his study of the reactions of mosquitoes to chemicals, reported moderate success with certain of the essential oils and with pyrethrum oil extracts when used against salt marsh mosquitoes. Moore (1934) found certain terpene esters better than related alcohols or hydrocarbons. Recently, MacNay (1939) reported successful use of a mixture consisting of concentrated oil extract of pyrethrum, oil of thyme, and castor oil, against *Aedes* species in Canada.

PROPERTIES OF AN IDEAL REPELLENT.—A repellent to be generally acceptable should possess other properties, in addition to that of lasting effectiveness against mosquitoes. It should be odorless or have a pleasing odor; non-irritating when applied to the skin and harmless when breathed or accidently consumed; have no effect on clothes, such as staining, bleaching or weakening of fiber; leave no objectionable "oily" appearance or feel on the skin; repel other biting insects such as black flies, *Simulium* spp., sand flies, *Culicoides* spp., and stable flies, *Stomoxys calcitrans* (L); be economical, and chemically stable. As no repellent was available which approached these qualities, an investigation* was started in 1935 to discover or develop a better repellent substance.

SCOPE OF WORK AND RESULTS OBTAINED.—In the course of this investigation, we have tested nearly 1,000 selected organic chemicals and chemical mixtures, including many materials recommended by others, plus about 40 products sold under proprietary brand names.

This work has led to the development of a repellent composed of diethylene glycol monobutyl ether acetate, diethylene glycol monoethyl ether, ethyl alcohol, corn oil, and perfume, a mixture now sold under the trade name of "*Sta-Way Insect Repellent Lotion.*"

Results from this repellent mixture have been highly satisfactory on three scores:

First: Long repellent time,—it outlasts all known usable compounds by a substantial margin.

Second: Desirable accessory properties,—it has a pleasing odor, is non-irritating to the skin, is not greasy nor unsightly on the skin, and is inert to natural fibers.

Third: Effective against many blood-sucking pests in addition to mosquitoes. This product is unsatisfactory in that, like other mosquito repellents, it injures paints, varnishes, lacquers and certain plastics and affects cellulose acetate fiber.

* Under a Fellowship at Rutgers University sponsored by the National Carbon Company.

Table 1.—Relative effectiveness of various repellent substances tested in the field against mosquitoes, principally *Aedes sollicitans* and *Aedes cantator*.

REPELLENT	NO. OF TESTS	BITING FREQUENCY RANGE	REPELLENT TIME RANGE		REPELLENT RATING[2]
		Bites per Min. on Untreated Areas	Product Tested	Reference Standard at Same Range of Biting Rates[1]	
			Minutes	Minutes	Per Cent
Reference Standard (*Sta-Way Lotion*)	49	26–1	67–136	—	100
SELECTED CHEMICALS					
Oil of Citronella	41	21–1	40–87	70–136	65
Citronellol	2	1.5–1	60–95	130–136	58
Terpinyl Acetate	2	2–1.5	25–35	122–130	24
Butyl Salicylate	2	20–18	5–10	70–72	10
Amyl Salicylate	2	1.5–.5	5–15	130–140	8
Ethylene Glycol	2	2–1.5	10–10	117–122	8
Pine Oils—Steam Distilled:					
Medium Fraction	4	21–4	30–65	70–104	59
Light to Medium	2	1.5–.5	35–50	130–140	31
Pyrethrum Mixtures:					
100% 20–1 Oil Extract	2	1.5–.5	45–50	130–140	34
25% 30–1 Oil Extract 12.5% Oil of Thyme 62.5% Castor Oil	2	9–5	35–40	83–97	41
Fly Spray Type: 5% 20–1 Oil Extract 95% Refined Kerosene	3	6–2	15–25	92–122	17

[1] = Repellent times of reference standard at biting frequency rates indicated were read from Curve 1, Figure 1, "Studies of Mosquito Repellents: I."

[2] = The repellent time of the tested product divided by the repellent time of the reference standard product at the same biting rate.

If the repellent time of the compared product is tested at several biting levels, the ratings at the different levels are averaged to a single comparative value.

SCOPE OF REPORT.—This paper will deal with the relative effectiveness of this repellent as compared to other repellent materials and in addition, will consider those factors other than repellency which are important for satisfactory use of any repellent.

The preceding paper described the method of field testing and of evaluating the results. Test procedure involves determining biting frequency (bites per minute on untreated areas) during the test period and observing the repellent protection time (time in minutes to first bite on corresponding treated areas). The newly developed repellent, *Sta-Way Lotion*, is used as a reference standard. Thus, for rating purposes, the repellent time of the compared product is divided by the repellent time of the reference standard at the same biting frequency. If the compared product is tested at several biting levels, the ratings at the different levels are averaged to give a single comparative value.

EXPERIMENTAL DATA.—At the outset, tests with various recommended materials tended to show that under New Jersey conditions, especially in regions where salt marsh mosquitoes abounded, repellent protection time was considerably less than reported by other investigators in other localities for different mosquito species. For instance, the pyrethrum oil mixture which MacNay found effective for several hours against fresh water mosquitoes, mainly *Aedes hirsuteron* and *Aedes stimulans* in Canada, lasted only about one-half hour in our tests against salt marsh mosquitoes, *Aedes*

Table 2.—Relative effectiveness of various proprietary repellents tested in the field against mosquitoes, principally *Aedes sollicitans* and *Aedes cantator*.

Repellent	No. of Tests	Biting Frequency Range Untreated Areas	Repellent Time Range		Repellent Rating[2]
			Product Tested	Reference Standard[1]	
		Bites per Min.	Minutes	Minutes	Per Cent
Organic Mixtures					
Reference Standard (*Sta-Way Lotion*)	49	26–1	67–136	—	100
PR2	9	25–3	45–70	73–112	66
PR3	6	11–3	20–40	80–112	35
PR4	13	23–2	5–45	66–122	22
Essential Oil Mixtures, Citronella Predominating					
Liquids					
PR5	2	12.5–4.5	65–75	75–100	80
PR6	3	7–3	40–55	88–112	51
PR7	3	6–2	15–60	97–122	37
PR8	2	3–2	35–45	112–122	34
PR9	4	13–3	25–30	77–112	31
PR10	2	4–2	25–25	104–122	22
PR11	2	40–12	10–15	54–78	20
PR12	2	12–4	15–20	78–104	19
PR13	2	12–3	15–15	78–112	16
PR14	2	15–4	10–10	75–104	11
PR15	2	5–2	10–10	97–122	9
PR16	4	8–6	7–10	86–92	9
PR17	4	9–6	2–5	83–92	4
PR18	1	1	10	136	7
PR19	2	40–19	2–2	55–75	3
PR20	2	12–3	5–5	78–112	6
PR26	4	8–2	10–60	86–122	29
Creams or Petrolatum					
PR21	4	10–5	20–40	81–97	29
PR21A	2	16–5	15–25	75–97	24
PR22	2	12–3	10–10	78–112	11
PR23	4	7–4	5–7	88–104	6
PR24	2	7–3	5–5	88–112	5
PR25	2	50–15	2–2	50–75	3
PR25A	4	7–4	5–5	88–104	5
PR25B	4	9–3	2–5	83–112	4
Tar Oil Mixtures					
PR27	2	18–4.5	20–25	72–100	28
PR28	2	1–1	30–40	136–136	26
PR28A	2	18–4	20–25	72–104	26
PR29	2	3–1.5	10–10	112–130	8
PR30	2	40–14	2–2	54–76	3
Pyrethrum Extracts in *Creams*					
PR31	2	4–2	15–15	104–122	13
PR32	7	4–1	5–8	104–136	5
PR33	2	12–3	5–5	78–112	5
PR34	7	6–1	4–10	92–136	6
PR35	2	6–3	5–5	92–112	5
PR36	1	1	5		3
Composition Unknown					
PR37	2	2–0.5	5–20	122–140	9
PR38	2	6.5–6.5	5–5	90–90	6
PR39	4	9–6	3–5	83–92	5
PR40	4	6–2	10–15	92–120	12

[1] = Repellent times of reference standard at biting frequency rates indicated were read from Curve 1, Figure 1, "Studies of Mosquito Repellents: I."

[2] = The repellent time of the tested product divided by the repellent time of the reference standard product at the same biting rate. If the repellent time of the compared product is tested at several biting levels, the ratings at the different levels are averaged to a single comparative value.

sollicitans and *Aedes cantator*. Amyl salicylate which Mail reported as effective for about two hours in Montana gave less than one-half hour protection under New Jersey conditions. It has previously been pointed out that such factors as the tester's personal attractiveness to mosquitoes, tests made in sunlight or shadow, time of day or night, prevailing temperatures and other weather conditions have an important bearing on the test results. We have attempted to include the effect of these factors by measuring the insect activity while determining the repellent time. The fact remains that the conditions under which most of our tests were made appear to be more severe than those usually prevailing elsewhere. Consequently, the repellent time reported in this paper for many materials is probably somewhat lower than may generally be expected in localities other than those infested with salt marsh mosquitoes. Mention might also be made that although repellent time for the treated area has been taken as the time to the first bite, partial protection was often evident for a considerably longer period. This was indicated by an occasional bite on treated areas as compared with numerous bites on untreated areas.

SELECTION OF MATERIALS ON WHICH DATA IS GIVEN.—The materials whose performance data is given have been divided into two main classes, selected chemicals in table 1 and proprietary products in table 2, on the following basis:

Chemicals: Excluded from the list are:

1. Those chemicals whose accessory properties, usually skin irritation, makes them unsatisfactory for practical use.

2. A few organic compounds which are difficult to procure and prohibitive in cost.

3. Compounds closely related to the repellent chemicals in *Sta-Way Lotion*.

Of the many chemicals still remaining, we have listed oil of citronella and ten typical chemicals and mixtures running down the scale of repellent effectiveness. Data is presented on a number of pine oil and pyrethrum mixtures because of the general belief in the high order of protection afforded by these mixtures.

Proprietary Products:—All the proprietary products tested against mosquitoes outdoors have been designated by code number. Omitted from the table are twelve products shown to be poor repellents by preliminary trials against captive mosquitoes and therefore not given further tests in the field.

Most of the listed proprietaries have been grouped according to their most active repellent compound. Distinction has also been made between liquid and semi-solid products of the cream or petrolatum type.

The compositions of some of these proprietary repellents are given in the supplementary table 3.

Table 3.—Composition of Certain Proprietaries.

Reference			
Standard (Sta-Way Lotion)			
Active Ingredients			
Diethylene glycol monobutyl ether acetate	65%		
Diethylene glycol monoethyl ether			
Inactive Ingredients			
Alcohol	28%		
Corn Oil	7%		
	100%		
PR12			
Oil Citronella		Oil Camphor	
Oil Lavender		Mineral Oil	
PR23			
Oil Wormwood	4.0%	Alum	5.0%
Oil Peppermint	1.0%	Sodium Para-chlormeta Cresol	0.1%
Oil Rosemary	0.5%	Inert	88.9%
Oil Lavender	0.5%		
PR32			
Active Ingredients			
Oil Citronella	3.5%	Oil cedarleaf	0.5%
Oil Camphor	0.5%	Pyrethrum	2.0%
Oil Pennyroyal	0.5%	Inert	93.0%

DISCUSSION—REPELLENT PERFORMANCE AND RATING.—The top ranking products and their ratings are:

Reference standard (*Sta-Way Lotion*)	—100%
Proprietary	
PR5 containing citronella	— 80%
PR2 containing synthetic organic repellents	— 66%
Undiluted Citronella	— 65%
Pine Oil, medium fraction steam distilled	— 59%

Undiluted citronella, which stands at the head of all the usable chemicals tested (except those of the reference standard) is outranked by the proprietary *PR2* containing synthetic organic repellents and *PR5* containing citronella. We believe the performance of *PR5* is to be accounted for by the fact that it is an exceptionally thick and oily liquid, and that its ex-

cessively viscous properties act as a mechanical barrier to mosquitoes.

While not indicated by the performance data in the table, it was observed that mosquitoes began to alight on areas treated with *PR2* within 30 minutes of application, although biting did not begin until much later. The movement of these non-biting mosquitoes was annoying.

The less volatile pine oil fraction lasted longer, probably because it remained longer on the surface of the skin.

Of the pyrethrum mixtures tried, only the straight concentrated oil extract or a mixture of this with oil of thyme and castor oil, had a repellent time of over 30 minutes and a rating of only 41 per cent for the best of the lot.

The pyrethrum extract repellents exert a peculiar effect on mosquitoes. Fifteen or twenty minutes after the application of such a mixture the mosquitoes may begin to alight, pierce the skin a short distance and then fly off without feeding. It is as if the active principle of the extract had been absorbed a short distance below the skin surface and the insect did not detect the presence of the chemical until it had pierced the skin in the act of biting. Whatever the cause this pricking of the skin is almost as annoying as an actual bite.

The majority of proprietary mixtures, other than the few known to include synthetic organic compounds contain oil of citronella or some other essential oil as the active ingredient. The variation in results obtained with these products is probably in large measure attributable to the varying concentrations of active ingredients employed. Except those previously mentioned, all the proprietary compounds rated less than 60 per cent, many being in the 10 and 20 per cent brackets.

REPELLENT TESTS AGAINST OTHER PESTS.—Because of its effectiveness against mosquitoes, the newly developed repellent (*Sta-Way Lotion*) was tried against other biting pests when they were causing moderate to severe annoyance. Application of this repellent to exposed parts of the person, prevented bites from black flies, *Simulium* spp., for 60 to 100 minutes. To prevent these insects from crawling underneath clothing and inflicting their irritating bites, it was found especially useful when applied to places where the clothing was open such as on neck, wrists or ankles.

Sand flies, *Culicoides* spp., were prevented from biting for 30 to 50 minutes, although they could not be entirely prevented from coming in contact with skin.

Stable flies, *Stomoxys calcitrans*, were repelled for 15 to 55 minutes and deer flies, *Chrysops* spp., were repelled for 25 to 55 minutes. Where deer flies were numerous, they were more annoying than stable flies because of their habit of hovering about the head.

The repellent times obtained with the reference standard against other biting insects is generally less than for mosquitoes. However, the application of this repellent is a distinct aid in reducing annoyance from all these insects, even though more frequent application is needed than is usually necessary for mosquito protection.

It is interesting to note that in a number of comparative tests it was also found that the reference standard mixture retained approximately the same relative superiority over different proprietary mixtures for these other biting insects as for mosquitoes.

REPELLENT TESTS AGAINST CHIGGERS.—Some trials were made of repellency of the reference standard repellent to chiggers, *Trombicula* spp. in Florida. These minute arthropods, a common pest in the southern states, attack the legs of those walking in grass or fields, and generally cause intense itching at shoe tops or where clothing comes in close contact with the skin. Application of the repellent to legs appeared to prevent biting of these parts for several hours. In a series of 8 tests 43 bites were received on untreated legs, while the treated legs during the same period received 7 bites. Reports from other individuals confirm the protective nature of the reference standard against chiggers.

ODOR AND SENSATION ON THE SKIN.—A satisfactory repellent will be used under all kinds of conditions and by various types of people. The pine oils and combinations containing essential oils are often greasy or excessively oily and their odors are objectionable to many. The odors from such mixtures are often absorbed and retained by the skin and clothes for extended periods, long after repellency has disappeared.

The proprietary synthetic organic repellents, including the reference standard, are satisfactory with respect to odor and

lack of oily feeling on the skin. Moreover, they do not impart the shiny appearance produced by many of the oil containing products.

PHYSIOLOGICAL EFFECTS.—In the development of the new repellent mixture, a series of physiological tests were made on human and animal skin, with the individual ingredients and with the finished product, to determine any possible irritant or systemic toxic effects produced by the repellent. These experiments took the form of 1 hour and 24 hour cloth patch tests on 75 persons of both sexes, observations of large scale use of the repellent under varied conditions, and daily applications of measured quantities to shaved rabbit's skin over a period of several weeks. The conclusion drawn from this phase of the investigation was that no adverse effect is likely to be experienced from use of this product on normally healthy skin. Applications made while perspiring sometimes produced a momentary smarting effect.

Observations made during repellent trials of other materials indicated that with a few exceptions, the majority of proprietary mixtures are also harmless on the skin. A few caused an unpleasant heating sensation (repellents *PR12*, *15*, and *28* table 2) and some caused a noticeable smarting (repellents *PR7*, *14*, *17*, *20*, and *23*, table 2) especially when applied on the face.

As the reference standard repellent is very bitter to taste, it was considered unlikely that anyone would accidently consume a dangerous quantity. That a large safety factor exists is shown by experiments made on white rats, in which it was found that a dose of approximately 16 cc. of the reference standard per kilogram of body weight, administered as a single dose was fatal to half of the rats used.

EASE OF APPLICATION.—All insect repellents must be applied thoroughly to the part to be protected as the action of these repellents is such that an insect may bite a short distance from the treated area. The proprietary creams and grease-like products were found to be difficult to apply evenly and thoroughly, and tended to leave untreated spots where the insects could alight and bite. From the viewpoint of ease of application and effectiveness, liquids were superior to these other forms of repellents.

SOLVENT ACTION AND EFFECT ON CLOTHES.—The products containing synthetic organic compounds, including the reference standard, were found to possess a common fault. These products exert a partial solvent action on acetate rayon fabrics and on synthetic plastics, paints, varnishes and lacquers. This effect was not especially noticeable unless a considerable quantity was applied to any one spot. Common types of fabrics, other than the acetate rayon, such as cotton, linen, wool, silk and viscose rayon were generally not affected to any greater extent than by similar application of water.

Large scale use of the reference standard has demonstrated that its solvent action is not considered a serious drawback.

SUMMARY.—As a result of a study of chemicals for possible mosquito repellent properties, begun in 1935, a repellent product has been developed consisting of diethylene glycol monobutyl ether acetate, diethylene glycol monoethyl ether, ethyl alcohol, corn oil, and perfume.

Comparative tests with nearly one thousand materials show that this mixture is definitely superior as a mosquito repellent to any of the usable, available chemicals, and mixtures of them, which were tested. This mixture was also definitely superior to the forty-two representative proprietary products tested. In the chemical group, the runner-up was the familiar repellent, oil of citronella.

This newly developed repellent is on equal terms with others as regards its undesirable solvent action on certain organic materials. Experience of users clearly indicates, however, that they do not consider this property a serious drawback.

This repellent product was also found superior in its combination of accessory properties such as pleasing odor, lack of irritation, toxic effects or unsightly appearance when applied to normal skin and its harmlessness to all fabrics except acetate rayon.

In tests against blood sucking pests other than mosquitoes, such as black flies, sand flies, stable flies, deer flies and chiggers, more frequent applications of this new repellent are necessary to obtain satisfactory relief from annoyance. In general, however, it has the same relative order of superiority over other chemicals and proprietaries for these pests as it has for mosquitoes.—4-16-40.

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The Life History of *Phyllophaga lanceolata* (Say) and *Phyllophaga crinita* Burmeister*

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Various species of *Phyllophaga* are becoming increasingly important as pests affecting the production of agricultural crops in Texas. Hitherto, little or no biological work on any member of this genus has been done under the generally milder climatic conditions of the Southwest. In 1937, life history studies were begun as a project of the Texas Agricultural Experiment Station and the present paper is the first of a series intended to present essential life cycle data as secured for forms occurring in this region.

The species here under consideration are both of considerable economic importance. They are not closely related; in fact, occupy taxonomic positions rather widely separated in the *Phyllophaga* series. This may add an item of interest to the life history data given for each on the following pages, since the two species were reared simultaneously under practically identical conditions.

Rearing white grubs in desirable numbers under conditions of close confinement heretofore has not been a common accomplishment. In the present studies some progress in this direction has been made by certain improvements in rearing technique and particularly with reference to the food requirements of growing grubs. In the past workers have generally supplied confined larvae with sprouted kernels of grain as food material. All rearings attempted under such conditions were attended by a high rate of larval mortality and a more adequate diet seemed essential for increasing larval vigor.

Among the new kinds of foods used in preliminary rearing tests during 1937, grapenuts showed promise as a satisfactory diet for rearing white grubs in close confinement. This cereal has now been used in rearing work throughout the seasons of 1938 and 1939 and all records on larval development given below are based upon individuals which were fed exclusively on this diet while confined in 4-, 6-, and 8-oz. tin ointment boxes.

Phyllophaga lanceolata (Say).—This is one of the best known among the southwestern species of *Phyllophaga*. Say (1824) originally described the present form as *Melolontha lanceolata*, from specimens taken near the Rocky Mountains. Between the latter and the Mississippi River, the species ranges from southern Texas to South Dakota. Definite records of occurrence in Texas include 24 counties extending from Brazos and Kaufman on the east to Roberts in the upper Panhandle. Hayes (1919) has published a summary of economic references to the species, which include reports of damage by adults to truck crops and cotton in Texas. Although additional local cases of extensive damage by beetles to these crops have been noted during recent years, there seems little doubt that greater losses have resulted from larvae attacking young

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wheat in Northwest Texas. Severe injury to wheat has also been recorded recently in Oklahoma, where the larva of the species has been locally termed "the wheat grub." Beetles and larvae occur in native grass lands but the importance of the species as a pest of pasture grasses in the Southwest has not been established by any definite records.

Phyllophaga lanceolata, unlike most species of the genus, is diurnal in habit. The beetles range from 14 to 19 mm. in length, are brownish in color and are covered with closely appressed whitish scales, which effect a general grayish appearance. Form of the adult varies with the sex. The female is robust in build, with the elytra and abdomen noticeably distended behind. This sex possesses no functional wings. The male beetle, aside from its smaller size, is oblong or nearly parallel in form and has normally developed wings. These items at once distinguish the species from all related forms except possibly *P. squamipilosa* Saylor, which was recently described from a single specimen collected in Texas.†

Food plants listed for adults of *lanceolata*, Hayes (1919), and Travis (1939), include a wide range of annuals besides several species of deciduous perennials. Based on observations of beetles in feeding cages the following food plants may be added to the previously recorded lists: spinach, lettuce, carrot, cowpea, rape, turnip, mustard, onion, and Bermuda grass. In the field the beetles have been observed locally feeding on beans, cowpeas, and Irish potato, in addition to cotton. Excepting the last mentioned crop, the adults were noted feeding more commonly upon wild host species among which, primrose, *Oenothera speciosa* Nutt. and pigweed, *Amaranthus* sp. appeared to be the most common.

LIFE CYCLE.—*Oviposition* records secured from ten mated pairs of reared specimens are presented in table 1. The total number of eggs laid per female ranged from 36 to 85. However, since the beetles are comparatively short-lived under cage conditions during the warm season, it may be assumed that the egg laying capacity of the species might be considerably greater under natural conditions.

Table 1.—Number of eggs laid by reared adults of *Phyllophaga lanceolata*, College Station, 1939.

DATE 1939	NUMBER OF EGGS LAID									
	Pair 1	Pair 2	Pair 3	Pair 4	Pair 5	Pair 6	Pair 7	Pair 8	Pair 9	Pair 10
5/19	EP									
5/22	0	EP	EP	EP						
5/25	0	6	12	10	EP	EP	EP	EP	EP	
5/29	10	11	3	0	0	0	0	0	0	EP
6/3	16	15	13	10	0	0	2	0	2	0
6/7	17*	17	0	22	0	14	7	9	11	0
6/12	11	22*	8*	15	10*	14*	15*	14	41*	14
6/17	4	7**	0**	19	27	19	8	11*	16	20*
6/21	0**			4	6	10	6	5	9	6
6/26				2*	6	7	4**	4**	1**	6
7/3				3	6	3**				10
7/8				0**	0					2
7/13					1					0
7/21					0**					0**
Total	58	78	36	85	56	67	42	43	80	58

EP—emerged, paired.
*—male dead.
**—female dead.

Egg.—The eggs of *lanceolata* are laid in separately prepared cells within small clumps of soil from 2 to 8 inches beneath the surface. When first deposited, the egg is white, oval in shape and measures about 1.5 mm. in length. Within a few days the egg becomes spherical and increases in size to a diameter of nearly 3 mm. The dark mandibles of the embryonic larva become visible through the thin egg-shell several days prior to hatching. In incubation containers newly hatched larvae did not feed upon the remaining thin transparent tissue of the egg-shell.

Earliest egg deposition in the laboratory was recorded on May 25. This date

† Can. Ent. Dec. 1936, p. 280.

Table 2.—Duration of egg stage in *Phyllophaga lanceolata*, College Station, 1938–1939.

Date Laid	Number Larvae Hatched	Incubation Period Days			Temp. Av. Daily Mean
		Max.	Min.	Wt. Av.	
1938					
May 19–24	431	26	14	20.92	78.1
May 25–28	207	23	19	20.64	78.6
May 28–June 5	124	25	15	20.09	79.7
June 6–9	34	21	18	18.79	80.5
June 9–15	35	21	16	18.86	80.8
June 15–26	13	17	13	14.92	83.9
1939					
May 15–25	14	26	22	24.14	78.1
May 25–29	14	22	19	20.64	79.3
May 29–June 2	44	22	18	20.04	79.5
June 17–21	28	21	17	18.03	83.8
June 21–26	14	16	14	15.00	84.2
Average duration of incubation period				19.27	

approximates the time of maximum beetle emergence under both laboratory and field conditions. Since the preoviposition period as shown in table 1, averages about 10 days, it appears likely that egg deposition in the field is well under way by the first week of June.

The duration of the incubation period ranged from 13 to 26 days and averaged about 19.3 days. Table 2 shows a summary of the records secured during the seasons 1938 and 1939. All eggs were kept in tin ointment boxes containing moist sand. The average daily mean temperatures affecting the incubation period of each lot of eggs ranged from about 78 to 84 degrees F. The shortest periods of incubation were recorded in temperatures which averaged 80 degrees F. or above.

Larva.—The newly hatched larva averages about 3 mm. in length and is wholly white in color with the mandibles somewhat infuscated. The head soon turns brownish and following the first ingestion of soil the darker color of the latter becomes visible within a day or two in the distal portion of the alimentary tract. Young larvae with access to an ample supply of adequate food soon begin to feed and make rapid growth. Two molts occur during the active feeding period, and the winter is passed in the third instar or mature larval stage. Pupation from the third or final instar follows a third molt in the spring.

Two hundred and one larvae were caged separately in 4-, 6-, and 8-oz. ointment boxes containing moist soil for rearing observations. Of this number 10 mature larvae were preserved and 88 of the remaining individuals were carried successfully to the mature larval stage. A summary of the rearing records secured is presented in table 3. With reference to these data it should be pointed out that the interval between observations ranged from 10 to 14 days and hence the length of instars or developmental periods indicated are approximations. However, a good number of molts were noted on the exact date of occurrence so that the averages of about 51 and 51 days for the first and second instar, respectively, are seemingly close to the normal. The third larval instar, in

Table 3.—Duration of larval stage in *Phyllophaga lanceolata*, College Station, 1938–39.

Instar	No. of Larvae Observed	Number of Larvae in Instar for Period Specified									Weighted Average Days
		17–29 days	30–44 days	45–59 days	60–74 days	75–89 days	90–109 days	155 days	184–240 days	241–276 days	
First	201	6	108	71	11	5					44.92
Second	201	5	71	81	29	12	4				51.14
Third	88							1	64	23	231.21
Total larval period											327.27

which the winter is passed, ranged from 155 to 276 days, but a majority of the grubs required 6 to 8 months for this stage. Based upon weighted averages calculated for the duration of all instars, the total larval period comprised 327.3 days, indicating a one-year cycle for the species in the latitude of College Station.

Pupa.—The newly transformed pupa is pure white but within a day or two assumes a tawny tinge, which grows darker or reddish brown as transformation to the adult proceeds. The pupae average 15 to 18 mm. in length and 8 or 9 mm. in width. Pupation occurs within a cell previously prepared by the mature larva. When disturbed, pupae show some activity and are capable of changing position within the cell by squirming or twisting the abdomen.

Table 4.—Duration of pupal stage in *Phyllophaga lanceolata*, College Station, 1939.

Sex	No. of Pupae Observed	No. of Individuals in Pupal Stage for Days Specified												Weighted Average Days
		13	14	15	16	17	18	19	20	21	22	23	24	
Male	44		1	4	3	4	2	6	9	9	3	1	2	19.23
Female	32	1	3	5	2	2	1	1	12	1	1	2	1	18.31
Average duration of pupal period														18.97

Records secured on the duration of the pupal stage are briefly summarized in table 4. As determined in these studies the extremes of the stage may range from 13 to 24 days. The weighted averages calculated from 76 complete records indicate that males and females required about 19 and 18 days, respectively, for transformation and issuance as adults. The duration of the pupal period for both sexes averaged approximately 19 days.

SUMMARY.—The complete life cycle of *Phyllophaga lanceolata*, under Texas conditions, may be summarized briefly as follows: The beetles emerge in maximum numbers in May and egg deposition begins during the same month. The average duration of the egg stage is 19 days. Larvae, with access to an abundance of food, develop rapidly and attain full growth within a period of 3 to 4 months. Pupation begins by mid-April of the following spring and pupae are commonly present early in May. The duration of this stage averages nearly 3 weeks so that the total time required for the development of a complete generation is one year. This period apportioned among the three developmental stages is about as follows: egg, 19 days; larva, 327 days; and pupa, 19 days.

Phyllophaga crinita (Burmeister).—The taxonomic history of the species is brief. It was originally characterized from Mexico by Burmeister (1855) under the name *Trichestes crinita*. The following year LeConte (1856) described *Lachnosterna glabripennis* as a new species, which Horn (1887), who saw the type series, pronounced a synonym of *crinita*. Glasgow (1916) referred the species to *Phyllophaga* and the combination, *Phyllophaga crinita* (Burmeister), is now generally considered valid.

There are seemingly no references to the species in the economic literature of this country, but during recent years it has been definitely associated with other forms injurious to truck crops and lawns in various parts of Texas. *Phyllophaga crinita* is especially abundant in the Lower Rio Grande Valley. The following records may be cited to illustrate this statement: On May 16, 1936, 3,597 beetles (2050 males, 547 females) were taken at Donna in one light trap over a period of 30 minutes. A second record made at Weslaco on May 17, 1937, shows 947 specimens taken in one light trap kept in continuous operation from 8:30 to 10:30 P.M. There are many additional records, taken over a series of years, to indicate that the species may be considered the predominant form in South Texas. Northward it occurs less abundantly, ranging through the west-central part of the State to Hardeman County. Langston (1927) recorded *P. crinita* from Mississippi under the name *P. antennata* Smith,* and listed pecan as the only known food plant. Besides the latter, also noted as a food plant of the species in

* Two specimens received from J. M. Langston in 1930 labeled Jackson, Miss., June 1927 (R. H. Kimball) are *Phyllophaga crinita* Burm. as considered in this paper.

Table 5.—Number of eggs laid by reared adults of *Phyllophaga crinita*, College Station, 1939.

DATE 1939	NUMBER OF EGGS LAID						
	Pair 1	Pair 2	Pair 3	Pair 4	Pair 5	Pair 6	Pair 7
5/22	EP	EP	EP				
5/25	0	0	0				
5/30	0	0	4	EP	EP	EP	EP
6/3	36	34	39	0	0	0	0
6/8	34	27*	18*	2	4	2	0
6/13	12*	9	0**	7	8	10*	4
6/17	0**	0**		11*	14	12	7
6/21				20	16	10	19*
6/26				0	4*	5	2
7/1				0	0**	0**	0**
7/8				0**			
Total	82	70	61	40	46	39	32

EP—emerged, paired.
* male dead.
** female dead.

Texas, adults of *crinita* have been observed by S. W. Clark feeding upon the foliage of citrus and *Tamaria* sp. at Weslaco.

In the larval stage the species is an important enemy of cabbage and has also been associated with injury to corn in the region of the Lower Rio Grande Valley. Parsely is also subject to extensive injury by white grubs and *P. crinita* is probably one of the more important forms concerned in occurrence of such losses. During 1938 heavy populations of *P. crinita* grubs were observed in Buffalo grass lawns near Spur, Texas. These infestations produced considerable damage over limited areas and the beetles resulting therefrom emerged in maximum numbers about the middle of June.

In common with most other members of the genus, *Phyllophaga crinita* is winged in both sexes and nocturnal in habit. The beetles range from 12 to 17 mm. in length, are yellowish to reddish brown in color, with the surface above glabrous except the head and thorax, which are clothed with longish erect hairs. The bare elytra and the unusually long antennal club of the male in *P. crinita* at once distinguish it from both *P. lenis* and *P. tristis*, which are perhaps the most nearly related species.

LIFE CYCLE.—The data accumulated on oviposition and all developmental stages of *P. crinita* were recorded under conditions comparable with those mentioned under *P. lanceolata*. The corresponding stages from egg to pupa in the two species are similar in general aspect, and to avoid needless repetition descriptive items for *P. crinita* are omitted except in cases of obvious differences.

Oviposition.—During May and June, 1939, seven pairs of *P. crinita* beetles were caged for records on oviposition. The data secured are given in table 5. As determined in these observations the preoviposition period averaged slightly over 7 days and the duration of the oviposition period ranged from 3 to 5 days. The latter period

Table 6.—Duration of egg stage in *Phyllophaga crinita*, College Station, 1938–1939.

DATE LAID	NUMBER LARVAE HATCHED	INCUBATION PERIOD DAYS			TEMP. AV. DAILY MEAN
		Max.	Min.	Wt. Av.	
June 6–15, 1938	32	16	11	12.62	80.3
June 15–26	30	18	9	12.00	81.6
May 23–30, 1939	33	16	10	12.24	78.1
May 30–June 2	74	15	13	13.76	78.9
June 2–8	37	19	12	13.91	80.1
June 13–17	31	15	11	13.10	82.1
June 17–21	47	14	10	11.55	82.7
Average duration of incubation period				12.71	

Table 7.—Duration of larval stage in *Phyllophaga crinita*, College Station, 1938–39.

Instar	No. of Larvae Observed	Number of Larvae in Instar for Period Specified							Weighted Average Days
		21–29 days	30–44 days	45–59 days	60–74 days	177–209 days	210–239 days	240–277 days	
First	83	49	15	17	2				33.82
Second	83	34	27	21	1				34.58
Third	81					43	24	14	212.89
Total larval period									281.29

may be considerably more protracted under natural conditions and probably the total number of eggs laid per female is greater than the records indicate for beetles in close confinement.

A summary of the available data on the incubation period required for *P. crinita* eggs is presented in table 6. In mean temperatures averaging about 80 degrees F., embryonic development was completed in 9 to 19 days and over the entire period of observation averaged about 13 days as compared with 19 days for *P. lanceolata* eggs incubated under comparable temperature conditions.

Larva.—The newly hatched larva soon begins to feed and develops rapidly in the presence of an abundant supply of suitable food. As in the case of *P. lanceolata*, two molts are required for the larva to attain full growth and the winter season is passed in this developmental stage. Transformation to the pupa occurs in the spring with the completion of the third or final larval molt. Out of a total of 83 newly hatched *P. crinita* larvae placed separately in 4- and 6-oz. ointment boxes, 81 individuals were reared to maturity. These records are briefly summarized in table 7. Calculated on the basis of individual rearing records, the duration of the first and second instar each was approximately 34 days. The last larval instar is greatly protracted by the winter season when the larvae remain more or less quiescent. The total larval period of *crinita* averaged about 281 days or nearly 46 days less than the corresponding stage for *lanceolata* under comparable conditions.

PUPA.—In the present species the pupa averages a trifle smaller in size than in *lanceolata* but is quite similar in other respects. The time required for transformation to the adult is also practically the same in the two forms. Out of a total of 81 *crinita* larvae under observation, 79 pupated successfully and emerged as beetles. The individual records secured are summarized in table 8. The minimum length of the pupal stage was found to be 16 days for both sexes and the maximum 27 and 31 days for male and female, respectively; the average for both sexes totaled approximately 20 days.

SUMMARY.—As determined in these studies the complete life cycle of *crinita* may be summarized as follows: The beetles begin to emerge in May and are commonly active throughout June. Earliest oviposition in the laboratory was noted on May 25 and the last on July 13. About 13 days are required for the eggs to hatch. The larvae continue to feed for two or three months and attain full growth during September or October after which they remain quiescent throughout the winter season. Pupation begins about mid-April and pupae occur commonly in May. Approximately 20 days are required for the pupal stage, from which the beetles begin to emerge in May to complete a one year life cycle. Under favorable rear-

Table 8.—Duration of pupal stage in *Phyllophaga crinita*, College Station, 1939.

Sex	No. of Pupae Observed	No. of Individuals in Pupal Stage for Days Specified												Weighted Average Days
		16	17	18	19	20	21	22	23	24	25	27	31	
Male	42	1	6	9	9	9	4	2	1			2		20.50
Female	37	4	5	5	7	3	5	3	1	2	1		1	19.73
Average duration of pupal period														20.11

ing conditions the average duration of the developmental stages was determined as follows: egg, 13 days; larva, 281 days; and pupa, 20 days. These periods total 314 days as compared with 365 days for *P. lanceolata*.—1-13-40.

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SCIENTIFIC NOTES

Mosquito Collections at Charleston, South Carolina, Using the New Jersey Light Trap

From July 19 to November 1, 1939 the mobile *Aedes aegypti* Control Unit of the U. S. Public Health Service was stationed at Charleston, South Carolina. In connection with the routine mosquito control activities of the unit a mosquito survey, using light traps, was made. This survey, extending from August 5 to October 19, doubtless revealed but a fraction of the mosquito species actually present and cannot be regarded as a complete sample of the mosquito population. Nevertheless this survey, even though incomplete, obviously could not be continued by the authors, and it will be presented as it stands.

Judging from the recent paper by King, *et al.* (1939) the mosquito records from South Carolina are relatively scanty. Of the sixty-two species occurring in the southeastern states thirty-six are recorded from Georgia, thirty-one from North Carolina, and only twenty-seven, from South Carolina. Hence it is not surprising that of the twenty-five species reported in this paper, nine of these are new records, increasing the total recorded from South Carolina to thirty-six.

The four mosquito traps used were of the New Jersey type, model 50, with the light, fan, and automatic timing switch of each electrically operated. They ran each night from 6:30 P.M. to 5:30 A.M. and were visited twice weekly. They were located in the north, east, south and west sections of the city. In table 1 the collections from all four traps are totalled together, the catches of the various traps not being significantly different from each other. In this table each species, or group of species, is listed by weeks along with the rainfall in inches and the mean maximum and minimum temperatures for that week. When these results are plotted graphically

Table 1.—Trap collections listed by weeks.

WEEK ENDING	AUG. 10	AUG. 17	AUG. 24	AUG. 31	SEPT. 7	SEPT. 14	SEPT. 21	SEPT. 28	OCT. 5	OCT. 12	OCT. 19	TOTAL
Anopheles crucians	11	7	3	24	21	8	8	21	35	48	4	190
Anopheles quadrimaculatus	0	0	0	0	0	1	0	1	3	1	1	7
Aedes infirmatus	0	2	1	0	1	13	1	9	1	1	0	29
Aedes (Group Serratus) spp.	5	0	1	0	1	6	0	6	1	0	0	20
Aedes triseriatus	0	0	4	0	0	0	0	0	1	0	0	5
Aedes aegypti	7	6	4	0	8	7	1	0	1	4	1	39
Aedes vexans	12	3	1	4	5	8	6	5	4	3	3	54
Aedes sollicitans	93	6	0	4	20	19	5	36	10	4	1	198
Aedes taeniorhynchus	1802	717	110	355	2315	1170	251	2439	530	130	31	9850
Culex (Culex) spp.	218	451	203	107	114	194	144	214	223	371	208	2447
Culex (Melanoconium) spp.	0	1	2	173	74	203	25	472	142	325	35	1452
Psorophora columbiae	1	0	2	3	1	0	1	0	0	0	0	8
Psorophora ferox	1	0	0	0	1	2	0	0	0	0	0	4
Psorophora ciliata	2	0	0	0	1	0	0	0	0	0	0	3
Orthopodomyia signifera	0	0	0	0	1	1	0	0	0	1	0	3
Uranotaenia lowii	0	0	0	1	10	5	0	23	35	124	10	208
Uranotaenia sapphirina	16	0	0	10	3	15	17	59	48	15	48	231
Total mosquitoes	2168	1193	331	681	2576	1652	459	3285	1034	1027	342	14748
Inches rainfall per week	1.58	0.70	1.41	4.52	0.22	0.14	0.13	0.67	0.73	T	T	Averages: 0.92
Mean maximum temperatures	88.1	87.2	89.3	82.5	87.3	90.9	81.7	82.0	78.0	83.6	72.2	83.9
Mean minimum temperatures	73.0	76.8	75.1	68.2	73.6	75.9	70.8	70.5	65.5	66.8	54.9	70.1

they show that warmer weather is generally accompanied by greatly increased trap catches, while the relation to rainfall is more obscure.

In table 2 all the mosquito species which were encountered at Charleston are listed. The numbers of each species trapped are added to show the relative abundance of that species in the light traps. Three of the species, marked (R) in the table, were never trapped but were reared from larvae collected in Charleston County. The nine asterisked species are those not recorded from South Carolina in King, Bradley, and McNeel's bulletin; and hence are evidently new records for the state.

Table 2.—Mosquitoe Species Encountered July 18 to Nov. 1, 1939.

SPECIES	TOTAL NUMBER TRAPPED
Anopheles crucians Wied.	190
Anopheles quadrimaculatus Say	7
**Aedes infirmatus* D. and K.	29
Aedes (Group *Serratus*) spp.	20
**Aedes atlanticus* D. and K.	
**Aedes dupreei* (Coq.)	
Aedes tormentor D. and K.	(R)
Aedes triseriatus (Say)	5
Aedes aegypti (L.)	39
**Aedes vexans* (Mg.)	54
Aedes sollicitans (Walk.)	198
Aedes taeniorhynchus (Wied.)	9850
Culex (*Culex*) spp.	2447
Theobaldia melanura (Coq.)	
Culex quinquefasciatus Say	
**Culex nigripalpus* Theob.	
Culex salinarius Coq.	
Culex apicalis Adams	
Culex (*Melanoconium*) spp.	1452
**Culex pilosus* (D. and K.)	
**Psorophora columbiae* (D. and K.)	8
Psorophora ferox (Humb.)	4
Psorophora ciliata (F.)	3
Psorophora howardii Coq.	(R)
Orthopodomyia signifera (Coq.)	3
**Uranotaenia lowii* Theob.	208
Uranotaenia sapphirina (O.S.)	231
**Megarhinus septentrionalis* D. and K.	(R)

(R) = Reared; not trapped.
* = New record for South Carolina.

The authors are greatly indebted to Entomologist Alan Stone of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, who kindly checked over the adult specimens and genitalia submitted to him and confirmed the identifications of all the species represented. Acknowledgment should be made to the City of Charleston and certain of her citizens who supplied locations and current for the traps. Acknowledgment is also due Junior Entomologist E. V. Welch, with the unit, who aided the senior author in separating and identifying some of the material.

SUMMARY.—In connection with *Aedes aegypti* control activities in Charleston, South Carolina, a mosquito light trap survey was carried on from August 5 to October 19, 1939. The necessarily short duration of the survey made it a poor sample of the total number of species present. Yet, of the twenty-five species found, nine were new records for South Carolina.—1-29-40.

FRANK W. FISK, *Junior Entomologist, and* JAMES H. LE VAN, *Passed Assistant Sanitary Engineer, United States Public Health Service.*

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Tartar Emetic Sprays Against Red Spider

During the spring of 1938 studies were undertaken for the purpose of finding whether the tartar emetic and brown sugar spray recommended for the control of the gladiolus thrips (*Taeniothrips simplex* (Morrison)) would be effective against the common red spider (*Tetranychus telarius* (L.)). In a preliminary test made on greenhouse cucumbers infested with the red spider three applications of a spray consisting of 4 pounds of tartar emetic and 16 pounds of brown sugar per 100 gallons of water resulted in 100 per cent kill. Rather serious burning of the foliage occurred, however, with a consequent reduction in the fruit yield. Because of the high mortality obtained in this first trial, it was considered desirable to make further tests on a fall crop of greenhouse-grown cucumbers. In these tests 2 and 4 pounds of tartar emetic were each combined with 8 and 16 pounds of brown sugar per 100 gallons of water. Single applications of these sprays resulted in kills ranging from 98.3 to 99.3 per cent. Only slight injury to the foliage occurred and this injury was more pronounced in the plots receiving the higher concentrations of tartar emetic. These plots also produced a lower yield of cucumbers.

In connection with the foregoing results it is of interest to record here an observation made by Floyd F. Smith, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, incidental to some greenhouse spray tests on the gladiolus thrips. Dr. Smith noted that the plots of gladiolus treated with tartar emetic and brown sugar spray were practically free from red spider whereas untreated plots were infested. The material exercised a prolonged residual effect in protecting the gladiolus, since the plants were practically free of mites six weeks after the last spray had been applied.

One serious objection to the use of the sugar mixtures is that they leave a sticky residue on the plants. Further tests under laboratory conditions were therefore undertaken with tartar emetic and brown sugar and with tartar emetic and other materials in an effort to find some new combination that would be as effective against red spider and would also eliminate the objectionable sticky residue. For this work carnation cuttings infested with red spider were employed. Individual cuttings were kept in separate bottles of water and each cutting was treated with a different spray combination. Each cutting was held in place by inserting the stem through a hole in the cork. This hole was then plugged with cotton and a thin ring of sticky tree-banding material was applied to the junction of the stem and the cotton plug to prevent migration of the mites from or to the carnation foliage.

The materials tested included various quantities

of tartar emetic (U.S.P.) in combination with different quantities of brown sugar, glycerin, dextrin, and a proprietary molasses-like by product of the corn syrup industry. Since Boyce & Persing (1939) had substituted glycerin for the brown sugar and reported promising results against the citrus thrips (*Scirtothrips citri* (Moult.)) on lemons, this material was included in tests against the red spider. The following proprietary wetting and spreading agents were tested as substitutes for brown sugar: a skim-milk product; refined white oil stock emulsion; sodium oleyl sulfate; sodium oleyl sulfate plus a synthetic resinous sticker; and sodium lauryl sulfate. In preliminary tests greenhouse-grown tomato had tolerated these materials in combination with tartar emetic.

The materials were applied as a fine mist from a small hand atomizer. Mortality counts were made 48 hours after treatment.

None of the treatments was replicated in any of the tests, but some of them were repeated in different series. Since the tests were conducted under laboratory conditions and with carnation cuttings, it was necessary to use only small quantities of the sprays. The various formulas used are expressed on the basis of 100 gallons of water.

The tartar emetic-brown sugar sprays gave high percentages of mortality as is shown by the following summary:

Mixture	Mortality Per Cent
Tartar emetic 4 lbs., sugar 8 lbs.,	94.3
Tartar emetic 2 lbs., sugar 8 lbs.,	96.8
Tartar emetic 1 lb., sugar 8 lbs.,	94.5
Tartar emetic 2 lbs., sugar 4 lbs.,	95.7
Tartar emetic 1 lb., sugar 4 lbs.,	86.0

These results agree with those obtained in the tests with cucumber, but the objectionable sticky residue was not eliminated even when the brown sugar was used at a rate as low as 4 pounds per 100 gallons.

When glycerin was substituted for the brown sugar, very encouraging results were obtained. Glycerin used at a rate of either 2 or 3 gallons, in combination with 2 pounds of tartar emetic, produced kills of 90.3 per cent and 93.4 per cent. When 1 gallon of glycerin was used in separate combination with 1, 2, 3, and 4 pounds of tartar emetic, mortalities ranging from 73 to 88 per cent resulted. When 2 quarts of glycerine were used with the same quantities of tartar emetic, kills ranging from 53.4 to 83.1 per cent were obtained. One quart of glycerin and 2 pounds of tartar emetic gave a 59.7 per cent kill. Therefore, with these quantities of tartar emetic and water 1 gallon or less of glycerin seems insufficient for consistently good control. Two or 3 gallons of glycerin in combination with 2 to 4 pounds of tartar emetic per 100 gallons of water would appear to be a satisfactory combination. Further tests are needed to establish this point.

A spray containing 2 pounds of tartar emetic and 3 gallons of the by product of corn syrup killed 89.9 per cent of the red spider, but it left a dark, sticky residue which was more objectionable than that from the brown sugar sprays.

Tests using 2 pounds of tartar emetic in combination with 4 pounds of dextrin and with 2 pounds of the proprietary skim-milk product showed very low kills. When 1 gallon of white oil emulsion was substituted for brown sugar, similar results were obtained, and this combination adversely affected the bloom on the carnation foliage. This condition would be objectionable since the bloom on the foliage contributes to the value of the cut flowers.

Sprays consisting of quantities of tartar emetic ranging from 1 to 8 pounds per 100 gallons of water plus 4¼ ounces of sodium lauryl sulfate, or 1¼ pints of either sodium oleyl sulfate or sodium oleyl sulfate with synthetic resinous sticker, resulted in very low kills.

Sprays containing either tartar emetic or brown sugar alone gave very low mortalities.

Untreated checks showed an average mortality of 9.1 per cent and water-sprayed checks a mortality of 11.9 per cent.

From the foregoing results it appears that, while tartar emetic and brown sugar sprays are effective against the common red spider, they leave an objectionable sticky residue on the plants. The indications are that a spray consisting of 2 or 3 gallons of glycerin and 2 to 4 pounds of tartar emetic per 100 gallons of water may be substituted without reducing the effectiveness and at the same time without leaving a sticky residue or a poison that would be washed off by the normal watering of the plants.—2-10-40.

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Inheritance of Resistance to Hessian Fly

The wheat variety Dawson is known to be highly resistant to the hessian fly (*Phytophaga destructor* (Say)) in California, and a study of the inheritance of this resistance in a cross between Dawson and the susceptible variety Poso indicated that it is controlled by two genetic factors (1936). Subsequent tests have indicated a resistance less pronounced than that of Dawson occurring in some wheat varieties and strains of the Java type. Two strains exhibiting this resistance are *Illinois No. 1 W 38* and *Illinois No. 1×(Norka×Carina)*, which were obtained from the Indiana Agricultural Experiment Station. These were crossed with Dawson and the

Table 1.—Comparative hessian fly infestations of parents and F_2 generation hybrids as determined from field counts at Birds Landing, Calif., in 1938.

Parent or Cross	Total Plants Observed	Fly-Infested Plants, Per Cent
Poso (susceptible check)	239	69
Dawson (parent)	98	0
Illinois No. 1 W 38 (parent)	162	9
Illinois No. 1 X (Norka×Carina) (parent)	104	31
Dawson×Illinois No. 1 W 38 (F_2 population)	1,534	16.8
Dawson×(Illinois No. 1×(Norka×Carina)) (F_2 population)	1,507	20.8

Table 2.—Distribution of parents and F_3 rows of named crosses among 5 per cent classes of hessian fly infestation as determined from field plantings at Birds Landing, Calif., in 1939.

Parent or Cross	Distribution of Rows by Indicated Percentage of Fly Infestation*																	Total Number Rows
	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	87.5	92.5	
Poso (susceptible)					1	2	0	1	2	0	5	1	2	1	2	2		19
Dawson	3																	3
Ill. No. 1 W 38	3	1																4
Ill. No. 1 × (*Norka* × *Carina*)	2	1	0	1	1													5
Dawson × *Ill. No. 1 W 38*	17	5	5	3	1	2	0	0	0	1	1	0	0	0	0	0	1	0	36
Dawson × (*Ill. No. 1* × (*Norka* × *Carina*))	170	25	11	7	3	6	2	0	5	1	2	0	1	0	1	0	0	0	234

* Percentages shown are class centers.

resultant hybrids have been tested during the past 2 years. The infestations by the fly during this period were insufficient for an exact factorial analysis of the data on the F_2 or F_3 generations, but the segregations observed are particularly suggestive and are inducive to continued inheritance studies.

Comparative hessian fly infestations of parents, hybrids, and susceptible checks for 1938 and 1939 are given in tables 1 and 2. In the tests of 1938 the susceptible Poso check averaged only 69 per cent infestation as compared with the range of 83 to 97 per cent average infestation recorded for the previous 6-year period. The infestation of the two F_2 populations in 1938 averaged higher than the previously studied *Dawson*×*Poso* F_2 (1936), even though two resistant parents were involved in the crosses. The infestations of the F_3 families in 1939 indicate that at least three heterozygous or susceptible families occurred in the cross *Dawson*×*Ill. No. 1 W 38* and at least ten in the cross *Dawson*×(*Ill. No. 1*×(*Norka*×*Carina*)). If the factor or factors for resistance in Ill. No. 1 W 38 and *Ill. No. 1* ×(*Norka*×*Carina*) were identical with one or both of those in Dawson, these families would not be expected in the crosses. The data therefore indicate that Ill. No. 1 W 38 and *Ill. No. 1*×(*Norka*×*Carina*) differ from Dawson by at least one factor for fly resistance. Further tests are in progress to confirm these results and to extend the research to other wheats resistant to the hessian fly.—3-23-40.

W. B. NOBLE and W. B. CARTWRIGHT, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*, and C. A. SUNESON, *U. S. Department of Agriculture, Bureau of Plant Industry, cooperating with University of California.*

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Destruction of an Experimental Population of Bean Weevil by *Pediculoides ventricosus* Newport

While working with the bean weevil, *Acanthoscelides obtectus* (Say), in a study of the effects of inbreeding on fertility and egg hatchability, an infestation of the mite *Pediculoides ventricosus* Newport broke out in the pedigreed stocks. The source of the infestation was a stock of *Bruchus quadrimaculatus* Fab. collected in the field and cultured in containers which were kept in the same incubator as the bean weevil cultures. The *B. quadrimaculatus* stock was collected near Athens, Georgia, in the fall of 1937 and all of the cultures were maintained at the University of Georgia. In pedigreeing the bean weevils, two-ounce salve tins were used for the individual pairs and their progeny. Some individuals of *B. quadrimaculatus* were reared in the same kind of containers. The bean weevil cultures were examined daily whereas the *B. quadrimaculatus* cultures were not. By the time the infestation in the latter was discovered, the young mites had spread from those cultures to all others in the incubator.

Chittenden (1898), Garman (1917), Larsen (1920), and others have noted the activities of the mite, *Pediculoides ventricosus*, in preying on bruchids. None of these authors mention it as attacking the eggs of Bruchidae. Several other authors have noted, however, that eggs of other species of insects are attacked by the mite.

In the pedigreed cultures of the bean weevil during the oviposition period, three beans, underneath which the females deposited their eggs, were placed in each container. When the first-laid eggs started to hatch, the bean weevil pairs were transferred to another containers and twenty or more beans were added to the original in order to insure sufficient food for the larvae. Under those conditions, excellent opportunities were afforded to observe the activities of the mites while they were invading the bean weevil cultures.

Although the lids of the salve tins in which bean weevil and *B. quadrimaculatus* were being cultured fitted snugly, young mites appeared to be able to leave or to enter them at will. The young mites seemed to prefer the eggs of the bean weevil as food. Soon after their discovery in the cultures, young mites were noted with their beaks imbedded in the eggs of the host. Occasionally two or three young mites would be feeding on the same egg. The mites would remove the entire content of the egg, leaving only the flattened chorion. Where several mites entered the same culture, all bean weevil eggs contained therein were soon destroyed.

If only one or two young mites invaded a single culture, not more than five or six eggs of the bean weevil would be destroyed by them. After feeding on the eggs for two or three days the young mites developed into gravid females and as such their abdomens became enlarged rounded masses. At the

temperature at which the cultures were maintained, 27 degrees centigrade, the gravid females produced young oviviparously on the average of seven days after they were first discovered in the culture. Some of the females produced as many as forty young a day three to four days after they started reproducing. The enormous number of young mites thus produced attacked and destroyed any unhatched eggs of the weevils, attacked and killed the newly hatched larvae before the latter had entered the beans, or followed the burrows of the larvae into the bean and destroyed them there before they had had a chance to develop to any great extent. Such cultures of the weevils were thus completely destroyed.

Where the young mites entered the bean weevil cultures after egg-laying by the latter had been completed and most of the eggs and hatched, they were largely limited in their activity to attacking only the larvae and pupae. In certain instances some of the bean weevil larvae escaped attack but in most such cultures the second or third generation mites found and attacked the older larvae and pupae. If the attack was made during late pupal development of the host, some individuals were able to emerge as adults. Many of these adults had elytra abnormal because there were as many as thirty or more mites underneath them; hosts in this condition at emergence would live only a day or so and did not lay eggs. Those weevils carrying only a few gravid female mites were able to fly and to deposit a few eggs. It is probable that in nature such hosts, that is the lightly infested ones, are very efficient in spreading the infestations.

Attempts to sub-culture families when infestation with the mite was apparent always met with failure. Even though no gravid females were carried by the adult bean weevils, one or two young mites, easily overlooked during examination, probably were transferred with the hosts. Attempts at differential etherization also were unsuccessful. The infestation was eliminated only when all cultures and used containers were put in the incubator and the temperature elevated to 60 degrees centigrade for a day, a process which killed all the mites free in the incubator as well as those in the culture tins. The extermination of the various lines of bean weevils was considered a great loss as many had been closely inbred for as many as six generations.—2-6-40.

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Minimum Size of Openings Through Which Clothes Moth Larvae Can Pass

The housewife may put away woolens free from all stages of clothes moths in boxes or other containers that are tight enough to prevent entrance of the flying moths and find, upon taking them out several months later, that they have become infested in some unknown manner. The mode of infestation is probably as follows: A female moth, in search of a place to lay her eggs where her offspring will be provided with food, locates a crevice in the box. Finding the crevice too small for her to pass through, she lays her eggs in it, so that the tiny larvae, which hatch a few days later, can crawl into the box among the woolens.

Tests have therefore been made to determine the exact size of the crevice through which a newly hatched larva of the common webbing clothes moth (*Tinola biselliella* (Hum.)) can pass. Glass microscope slides 3 inches long and 1 inch wide, with the centers hollow ground, were paired, the hollow surfaces facing each other. They were separated by bits of brass leaves cut from a "feeler" gauge, such as is used to space auto spark-plug gaps. Within the glass cell thus formed was placed uninfested wool. The whole was held together with rubber bands. Cells were made with crevices ranging in width from two-thousandths to ten-thousandths of an inch. Many of these cells were kept for a period of 30 days where there were large numbers of moths. At the end of this time it was found that all cells with crevices four-thousandths of an inch or larger had become infested with clothes moth larvae, whereas those with smaller crevices had remained uninfested.—3-22-40.

WALLACE COLMAN, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

The Golden Codling Moth; A Second Note

My reason for publishing a note on this interesting variety of the codling moth was to create sufficient interest to ascertain as thoroughly as possible the distribution of this variety of the codling moth throughout the apple-growing districts of the world. A letter dated February 20, 1940 just received from Mr. R. I. M. Prescott, Government Entomologist, Department of Agriculture, Victoria, Australia, is, I think, worth publishing in full as follows:

"I am very interested in your article in the recent number of the JOURNAL OF ECONOMIC ENTOMOLOGY, December, 1939, dealing with the Golden Codling Moth, *Carpocapsa pomonella* (L.) *var. simpsonii* Busck., and in your remarks on the distribution of this variety in the United States. I am passing on to you my experience with what I take is this species in Victoria.

"My attention was first directed to this unusual colour form of the Codling Moth two seasons ago in what we know as the northeastern district of this State. This district has one small apple-growing area, Stanley, which is situated at an altitude of roughly 2,500 feet and receives an annual rainfall of some 50 to 60 inches. In addition, it is a one-brood codling moth district, which naturally presents little difficulty from a control point of view. This variety of the codling moth was first observed in lure jars by our local orchard supervisor, and represented only some 2 or 3 per cent of the total catch of moth. During this season just reaching its completion, a commencement has been made with breeding experiments with this variety, but, up to the present, no results are available. This district is the only one in which this particular form has been noted.

"I would be pleased to hear from you on this matter, and, if you would like to have Victorian specimens of this moth to compare with your own specimens, I will forward same to you."—3-28-40.

E. O. ESSIG, *University of California, Berkeley.*

Effect of Lime Sulfur and of Oil Sprays on Treehopper Eggs and Emergence

It was established by the writer (Yothers 1924, 1934) that lime sulfur sprays at 3 to 4 degrees Baumé killed only about half as many eggs of the treehopper *Stictocephala inermis* (F.) as were killed by oil emulsion sprays containing 3 to 4 per cent of oil. For the purpose of determining why these results were obtained, additional observations were made which led to the following conclusions.

Eggs sprayed with oil emulsion may be saturated with the oil and as a result become shriveled and discolored and die. Or, only the outer tips and a small portion of the chorion may be saturated and in such cases the embryos appear normal within the chorion, but few of them are able to break through the hardened tip and emerge. Or, the outer tips alone may be burned and darkened and in that event the young emerge more or less normally to a certain point, but beyond that their progress is retarded by the toughened chorion and they are soon overcome by the heat and dry air and die without completing emergence.

Lime sulfur does not seem to penetrate the eggs sufficiently to kill very many of them nor does it appear to burn the tips of the eggs to the same extent as the oil. Many of the emerging young, however, are prevented from hatching in another way. Lime sulfur causes the bark about the egg slits to harden and become harsh and sharp-edged. When the hatching young attempt to push out of the egg slits the sharp edges of the bark retard or prevent their emergence and they soon die.—3-29-40.

M. A. YOTHERS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

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Food Habits of Sparrow Hawks in Utah

During recent years, large numbers of sparrow hawks, *Falco sparverius sparverius* Linn., have been observed on or around farms in many rural areas of Utah. The following report is based upon an examination of 81 stomachs taken from specimens collected since 1935. The method used in determining the number of grasshoppers present was to count the recognizable caudal ends of abdomens, as these usually remained intact until digestive processes were well advanced.

The clearly recognizable remains of 1,380 Orthoptera were present in the 81 stomachs examined, 79 of the stomachs containing a total of 1,345 grasshoppers (in addition to large quantities of grasshopper fragments which were too thoroughly digested to be readily determined as to number of specimens represented; also several hundred grasshopper eggs were present which evidently had escaped from torn abdomens of females which had been eaten); 26 field crickets and 9 sand crickets also were present. Several hundred of the grasshoppers were found to be in excellent condition and could be recognized to species; these consisted, roughly in the order of their abundance, of *Melanoplus femur-rubrum*, *M. mexicanus*, *M. bivittatus*, *Trimeratropus* sp., *Dissosteira carolina*, *Camnula pellucida*, *Aulocara elliotti*, *Arphia pseudonietana* and occasional specimens of less abundant species. This examination showed an average of 17 recognizable grasshoppers per stomach for the 79 hawks, plus other insect and rodent material in many of the stomachs. The stomach of one sparrow hawk, taken near Heber during September of 1939, where a serious grasshopper outbreak was in progress, contained 70 recognizable grasshoppers, mostly *Melanoplus femur-rubrum*, *M. mexicanus* and *M. bivittatus*. Ten hawks taken in this Heber area on the same cloudy day contained 441 mature grasshoppers, or an average of 44.1 per stomach; in addition the stomachs contained 3 lepidopterous caterpillars, 2 crickets, 4 beetles, 1 Myrmeleonid. One stomach contained two small mice while another held some mouse flesh and hair.

Coleoptera formed the next most important item of the food. Forty-eight of the 81 stomachs contained beetles or their recognizable remains. Fifteen cerambycid specimens were present in the stomach of a hawk taken among greasewood at Iospa on September 11, 1935 (this was the largest number of beetles found in any one stomach during the study). Other beetles included 6 Carabidae, 4 Elateridae, 2 Scarabaeidae, 39 miscellaneous beetles, and 1 each of the following: Curculionidae, Chrysomelidae, Coccinellidae, Staphylinidae and Silphidae, making a total of 71 Coleoptera. The presence of one coccinelid beetle in one of the stomachs was of interest because it is rather commonly believed that ladybird beetles are not eaten by birds. No adult moths or butterflies were found but 15 of the stomachs contained a total of 20 caterpillers, 6 of which appeared to be cutworm larvae. Eight stomachs contained Diptera, one specimen being an adult, the other 14 being maggots, most of these probably being *Sarcophaga kellyi*, larvae which are common internal parasites of grasshoppers throughout Utah. Eleven winged ants were present in four stomachs. Two Hemiptera, both Pentatomidae, and two Odonata, damselflies, were present, each in a different stomach. Numerous unidentifiable insect fragments also were present.

Non-insect material consisted of five spiders and one tick (the latter attached to a piece of rodent skin) in six stomachs. Seven stomachs contained flesh and hair or entire mice, apparently *Mus* and *Microtus*. Four stomachs each contained a lizard, the sagebrush swift, *Sceloporus graciousus graciousus*. Seven wheat kernels, grain hulls and a few pebbles also were present.

The above summary indicates that the sparrow hawk is preponderantly beneficial in food habits in spite of its occasional consumption of beneficial forms such as the one ladybird beetle, six ground beetles, two damsel-flies, several parasitic maggots, the few spiders and four lizards.

Several dozen sparrowhawks were observed lying dead along Utah highways during the past season. Many of these apparently were killed by passing automobiles although others undoubtedly were destroyed by fire arms.—2-2-40.

G. F. KNOWLTON and F. C. HARMSTON, *Utah Agricultural Experiment Station, Logan.*

Leafhopper Reaction to Lawn Sprinkling

The very marked relation between rainfall and the abundance of one common Puerto Rican grass-inhabiting leafhopper, *Cicadella (Kolla) similis* Walker, has previously been noted (Wolcott 1921). Mr. F. J. Juliá of the Isabela Sub-station reported in January 1940 an extensive outbreak of another, somewhat less common, grass-inhabiting leafhopper, *Kolla fasciata* Walker, in a casuarina-shaded lawn of "gramma" or St. Augustine grass, *Stenotaphrum secundatum*, on the outskirts of Aguadilla, P. R. The chalky white nymphs were present in considerable abundance, and adults averaged possibly several hundred to the square foot, mostly restricted to three circular areas ten or twelve feet in diameter. A month later, the leafhoppers were still present in small numbers, but the grass in the previously infested areas was dead. Seeking for an explanation of why the insects should have restricted their attack to such definitely marked areas, it was found that near the center of each was the nozzle of an underground pipe sprinkler system. It would appear that, in attempting to produce what were presumed to be optimum moisture conditions for the lawn during dry weather, such an exceptionally favorable environment had been created for one species of leafhopper that it became sufficiently abundant to kill the grass.—3-11-40.

GEORGE N. WOLCOTT and LUIS F. MARTORELL, *Agricultural Experiment Station, Rio Piedras, Puerto Rico.*

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Dichloroethyl Ether in Mineral Oil for Corn Earworm Control in Sweet Corn

The usefulness of mineral oil for protecting sweet corn ears against earworms (*Heliothis armigera* (Hbn.)) is limited by the character of the husks, being more effective in ears having long, tight husks than in those having short, loose husks. Since most of the sweet corn varieties now grown are characterized by ears with husks neither long nor tight enough to allow a suitably high percentage of control by the use of oil alone, a search was made for materials which when added to the oil would increase its effectiveness. It was found in March 1939 that pyrethrum extract (pyrethrins) would serve this purpose. But because this material was expensive and gave results that were not perfect when used at concentrations corn growers could afford, further studies were made during the summer of 1939. These studies, which were made by the writers while working independently, showed that oil containing dichloroethyl ether gave a higher degree of control than oil containing pyrethrins, at a much lower cost.

The results obtained by one investigator in treating sweet corn with mineral oil containing dichloroethyl ether are summarized in table 1. The corn was in three fields and was of the varieties Bantam Evergreen, Kancross, and Vangard. The ears were treated between September 2 and 6 and examined between September 11 and 14. The results of the second investigator are given in table 2. These tests were carried on in eight fields and with the following varieties of corn: Golden Cross Bantam, Whipple's Yellow, Marcross 13–6, and Maule's Lead-All. The ears were treated between July 31 and September 8 and examined between August 8 and September 19.

Table 2.—Effectiveness against corn earworm larvae of white mineral oils of 125 to 135 or 200 to 210 seconds Saybolt viscosity containing various percentages of dichloroethyl ether applied to ears of sweet corn. Experiments by B. B. Pepper.

PER CENT DICHLORO-ETHYL ETHER	NUMBER OF TESTS	NUMBER OF EARS	PER CENT EARS PROTECTED[1]	
			Range	Average
0.5	3	150	74.0– 76.0	75.3
1.0	13	650	84.0– 98.0	94.9
2.0	10	500	88.0–100.0	96.0
3.0	5	250	88.0– 98.0	95.2
4.0	3	150	96.0–100.0	98.7
5.0	5	250	92.0– 98.0	95.6
Checks	8	400	0 – 4.0	0.7

[1] Uninfested ears.

Mineral oil containing more than 3 per cent of dichloroethyl ether caused burning or rot of the silks and husks, but oil containing less than 3 per cent of this material did not injure the corn ears and gave practically as good control.

Table 1.—Effectiveness against corn earworm larvae of white mineral oil of 200 to 210 seconds Saybolt viscosity containing various percentages of dichloroethyl ether applied to ears of sweet corn. Experiments by G. W. Barber.

PER CENT DICHLOROETHYL ETHER	EARS		PER CENT EARS CONTAINING FOLLOWING TYPES LARVAL POPULATIONS AT HARVEST				TOTAL LARVA IN EARS	
	Number Treated	Per Cent Protected[1]	None (Protected)	Dead Only (Protected)	Live and Dead	Live Only	Number	Per Cent Dead
1	598	81.5	12.4	69.1	11.0	7.5	765	85.5
2	298	88.6	10.1	78.5	6.0	5.4	384	90.6
3	249	94.8	15.3	79.5	2.8	2.4	292	95.5
4	248	90.8	9.3	81.5	5.2	4.0	344	93.3
5	250	92.0	6.0	86.0	4.8	3.2	364	94.5
Checks	150	0	0	0	0	100.0	271	0

[1] Ears containing no live earworms at time of harvest.

Dichloroethyl ether is colorless and mixes with oil at once. The mixture may be applied with an oiler or other measuring device or by atomization. If applied to the ears after the tips of the silks have begun to turn brown, or within about a week after silk exposure has begun, this mixture acts as a contact insecticide and kills the ear-worms in the ears. It also seems to repel larvae that seek entrance after treatment. In mineral oils ranging in viscosity from 125–135 to 200–210 seconds, quantities of 0.7 to 1 cubic centimeter per ear gave the best results.

The writers tested treated corn ears repeatedly before and after cooking for evidence of a dichloroethyl ether residue that could be detected by flavor or odor. Throughout the summer and until the middle of September no flavor or odor due to the chemical could be noticed, although the corn was often eaten by persons who did not know that it had been treated. After the middle of September a dichloroethyl ether residue in some cooked ears was recognized by tasters. Since temperatures were relatively high before the middle of September and lower thereafter, it is believed that a correlation exists between the temperatures prevailing during the period of treatment and the presence or absence of residue at harvest. It is probable that the presence of detectable amounts of dichloroethyl ether in corn harvested after September 15 was due to slower evaporation of the chemical in the lower temperatures prevailing at that time. Since this question has not been decided definitely, dichloroethyl ether in oil can not be recommended for earworm control in sweet corn at present. This brief discussion is presented at this time, however, so that other investigators may have the opportunity of testing the material under as widely varying conditions as possible during the coming season of earworm activity.—5-9-40.

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HORTICULTURAL INSPECTION NOTES

THE Bureau of Entomology and Plant Quarantine, on March 15, 1940, modified the schedule for fumigating balled and burlapped nursery stock with methyl bromide for white-fringed beetle, by permitting an increase in the size of the soil balls to 7 inches in diameter, the shortening of the period of exposure to 8 hours, and the lowering of the temperature to 65° F. These modifications were published in circular B.E.P.Q. 503. A modification was also made in the methyl bromide schedule of Japanese beetle larvae under a revision of amendment No. 1 to circular B.E.P.Q. 499, dated March 22, 1940.

POTATO tuber moth quarantine of Idaho, Oregon, and Washington were revised in April. The conditions of certification include vacuum or atmospheric fumigation for infested potatoes, and are similar in the three States. The area designated as infested is lacking as to uniformity under the three quarantines.

NO PEACH nursery stock growing within 500 feet of chokecherry plants infected with the "X" disease of peach will be certified for shipment in Connecticut, according to requirements established for the growing of peach in that State.

OWING to the unusually large numbers of chinch bugs which appeared in the summer and fall of 1939 in sections of Ohio, Indiana, Illinois, Missouri, Iowa, Nebraska, Kansas, and Oklahoma, a Federal-State survey of such infestations was made in November and December, in 432 counties of the effected States. The indications are that, in the absence of unfavorable climatic conditions or other influencing factors during the winter and spring, outbreaks of chinch bugs may be expected in 1940 in all the above States. State pest-control officials estimate that 10,646,000 gallons of creosote may be needed for the control of these pests. An additional survey needs to be made to determine the probable needs of artificial control.

SECRETARY OF Agriculture Henry A. Wallace signed an order on April 5 calling for continuance of the Federal Japanese beetle quarantine, and extending the regulated area in Maryland, Ohio, Pennsylvania, West Virginia, and adding a single township in New York State. The special area from which the movement of fruits and vegetables by motortruck or refrigerator car is regulated was also extended to include New York City and surrounding districts, as well as additional area in Maryland, New Jersey, and Pennsylvania. Minor modifications were made in certification requirements.

THE Georgia quarantine relating to the European corn borer was revised April 1, 1940, to apply to 18 entire States and the District of Columbia, and to three counties of North Carolina. The Georgia embargo on the entry of peppers and pepper plants from areas infested with the pepper weevil, was extended to include De Soto and Hillsborough Counties in Florida, Avoyelles Parish, Louisiana, and Presidio County, Texas.

THE Michigan regulations relating to raspberry diseases have been reissued as Nos. 804 and 805, effective March 1, 1940. Two inspections during the growing season are still required, as well as the prompt eradication of infected plants. No more than two per cent of the plants may be infected with virus disease on the first inspection, and no more than one per cent on the second, to meet certification requirements.

AT THE urgent request of a large number of Virginia tomato growers of six "Northern Neck counties," the Commissioner of Agriculture of that State promulgated a quarantine effective April 1, 1940, on the tomato root knot nematode disease, requiring special certification of tomato plants shipped into or between these counties.

THE Bureau of Entomology and Plant Quarantine, as a result of further experiments in methyl bromide fumigation of produce for killing adult Japanese beetles, has authorized a reduction of the dosage from 5 pounds to 4 per refrigerator car at a temperature of 80 degrees F., the schedule having been found effective in killing beetles. This modification is published in supplement No. 2, dated June 1, 1940, by circular B. E. P. Q. 499.

CERTIFICATION requirements of the white-fringed beetle quarantine (Federal quarantine No. 72) were recently waived as to a number of restricted articles when consigned from certain areas where the infestation has been greatly reduced. This modification was made in circular B. E. P. Q. 485, fifth revision, dated May 24, 1940.

FEDERAL-STATE scouting for the Egyptian alfalfa weevil, *Hypera brunneipennis* Boh., was conducted in the spring in 12 counties in Arizona, 16 in Southern California, 3 each in New Mexico and Texas, and 1 in Nevada. A 25-acre infestation was discovered in a date garden near Tempe, Ariz. In the Yuma Valley, the pests were found in 34 sections of land, and larval specimens were picked up a few miles away in the North Gila and South Gila Valleys. An extension of the Yuma Valley infestation was also found on approximately 7 sections in the Winterhaven area, Imperial County, Calif. At Bard, three and one-half miles from Winterhaven, the weevils were found on approximately one-half section of land.

THE tomato pinworm quarantines of Oregon and Washington were revised on May 27, 1940, to add Arizona to the infested territory, and to provide a fourth formula, atmospheric fumigation with methyl bromide, under which the regulated products may be treated as a condition of certification. The quarantines are uniform as to designation of infested area except that Missouri is quarantined against in the Washington order but not in the Oregon promulgation.

THE pear psylla quarantine in Washington was revised May 27, 1940, to extend the regulated area to include 5 counties of that State and 3 counties in Idaho. In addition to the wide range of articles restricted in the original quarantine of March 11, 1940, the new restrictions apply also to grain and forage crops, and railway cars, trucks, and other vehicles.

THE requirements for certification of seed sweetpotatoes and sweetpotato plants in Alabama, as specified in Regulation 23 as reissued effective July 1, 1940, provide for inspection of the tubers in storage and of plants in the bed. The presence of steam rot, black rot, mosaic, or sweetpotato weevils precludes certification. The sanitation provisions are specified in the order.

WHITE-FRINGED beetle quarantine regulations of Louisiana, as revised May 1, 1940, provide authority for control and eradication measures within designated areas, and require the inspection or treatment of restricted articles shipped from the regulated area to points outside, or shipped from a control area to an eradication area.